THE HOUSE THAT JUNK BUILT

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Popular Science

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FAIL-SAFE SKIES

JANUARY 1993
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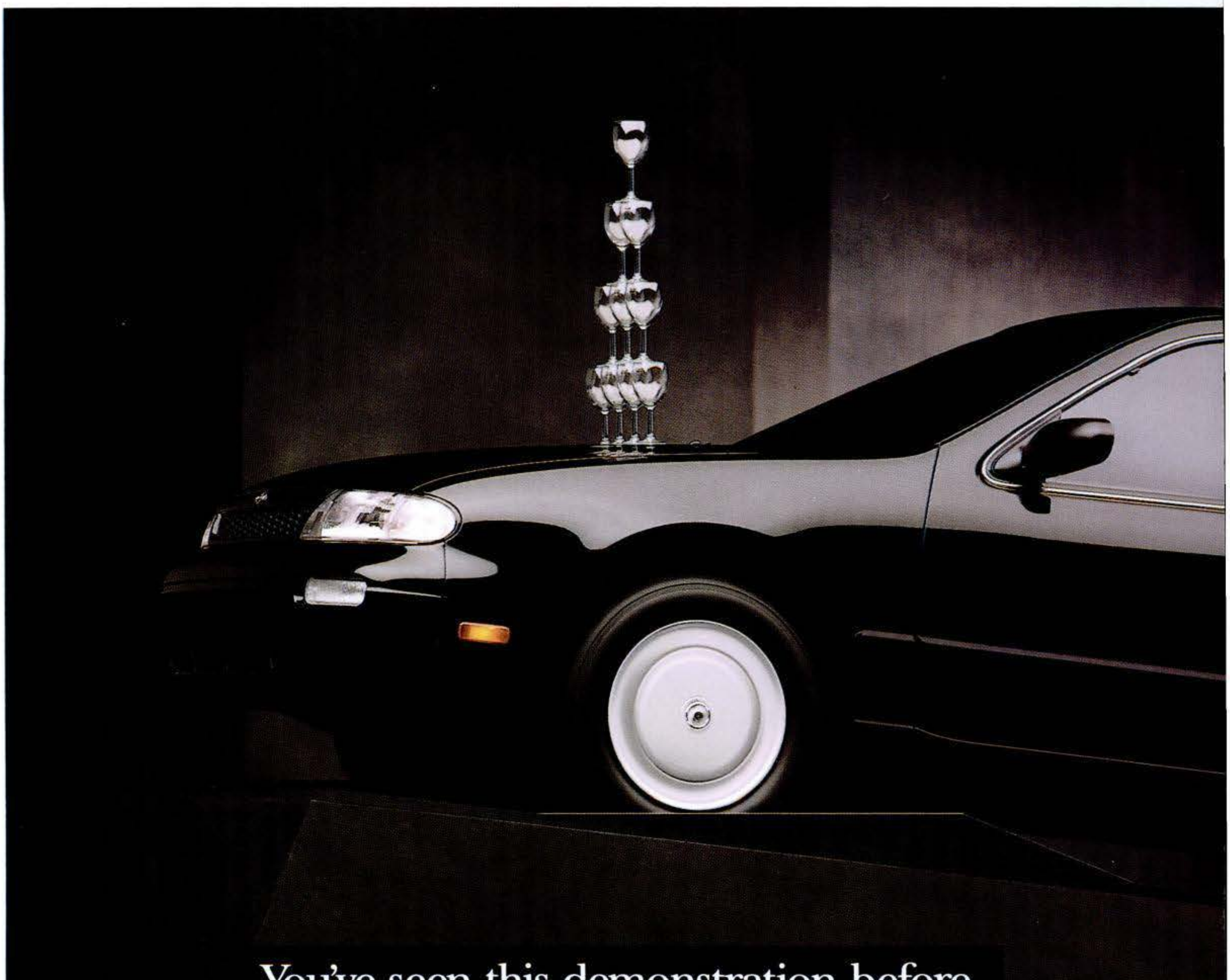

You've seen this demonstration before, but never for a $13,000* car.

The front wheels are on a dynamometer. Ten seven-inch glasses have been placed on its hood. The engine starts. The wheels turn. Quickly, the car reaches speeds in excess of 100 mph. The glasses remain in place, perfectly intact.** But all perceptions that a car has to be expensive to be exceptional have been completely shattered.

The new *Nissan Altima*™ has just arrived, and already automotive history has been made. A car that starts at $13,000* has just passed the luxury sedan entrance exam for smoothness of ride.

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It wasn't easy.

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*Nissan Motor Corporation in U.S.A. Smart people always read the fine print. And they always wear their seat belts. *Manufacturer's suggested retail price for Nissan Altima XE excluding taxes, title, license, destination charges and options. Manufacturer's suggested retail price for test vehicle (XE model with automatic transmission) is $13,824.*

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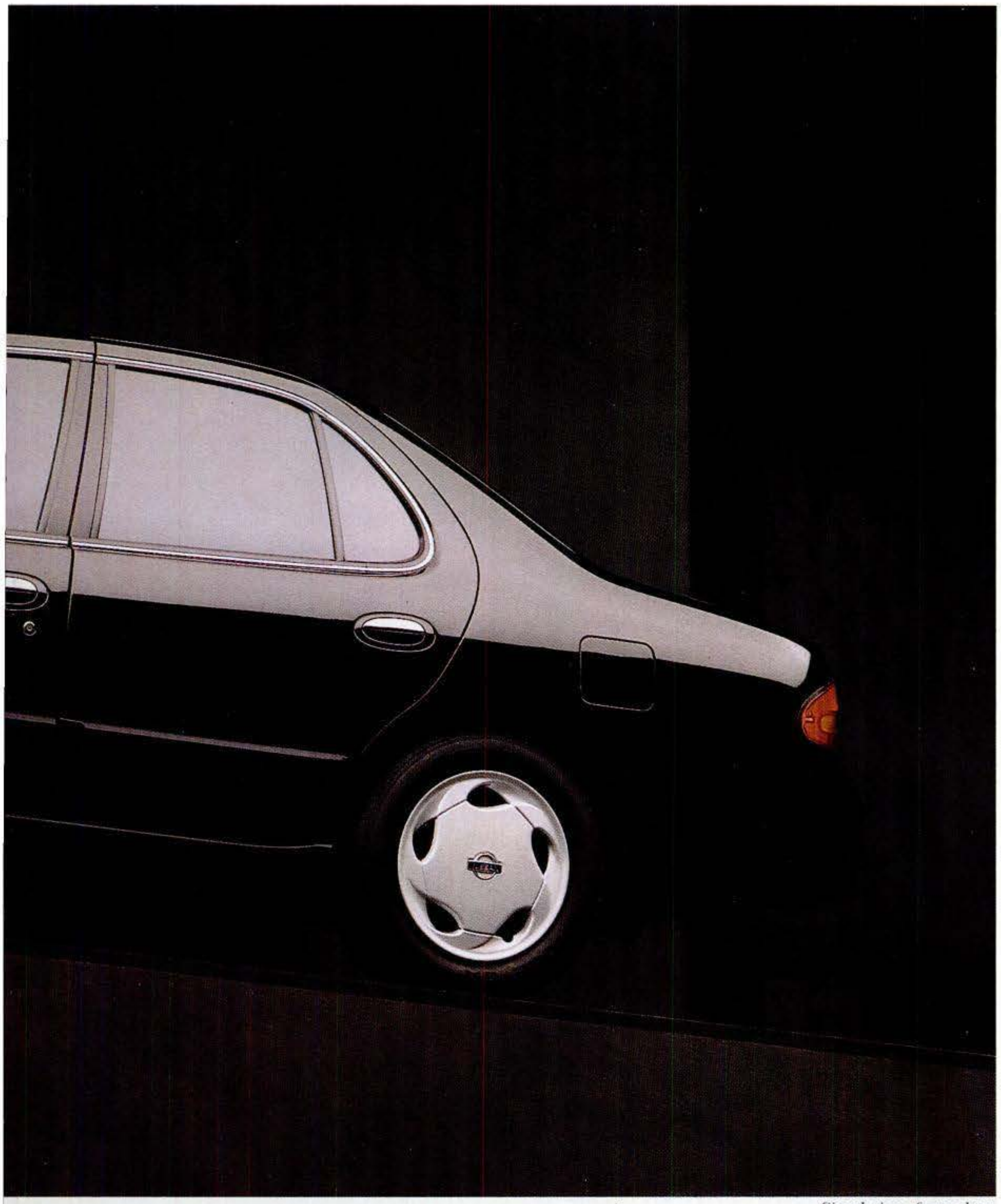

Simulation of actual test.

frames. Working in unison with four shock absorbers, the subframes serve as stabilizers—keeping wheel vibration isolated from the body of the car.

As a result of our efforts, the *Altima* is one of the most impressive Nissans ever built. And, quite possibly, the smoothest running $13,000 car in the world.

Okay, you know how well it performs on a dynamometer, but how does it do on the road?

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The New Nissan Altima

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***Based on independent tests conducted by AMCI. 1993 Nissan Altima XE or SE versus 1992 competitive vehicles. Merging power based on time and distance required to accelerate from 20-55 mph. Slalom comparison based on course completion time. Braking based on stopping distance from 50-0 mph on a wet road surface.*

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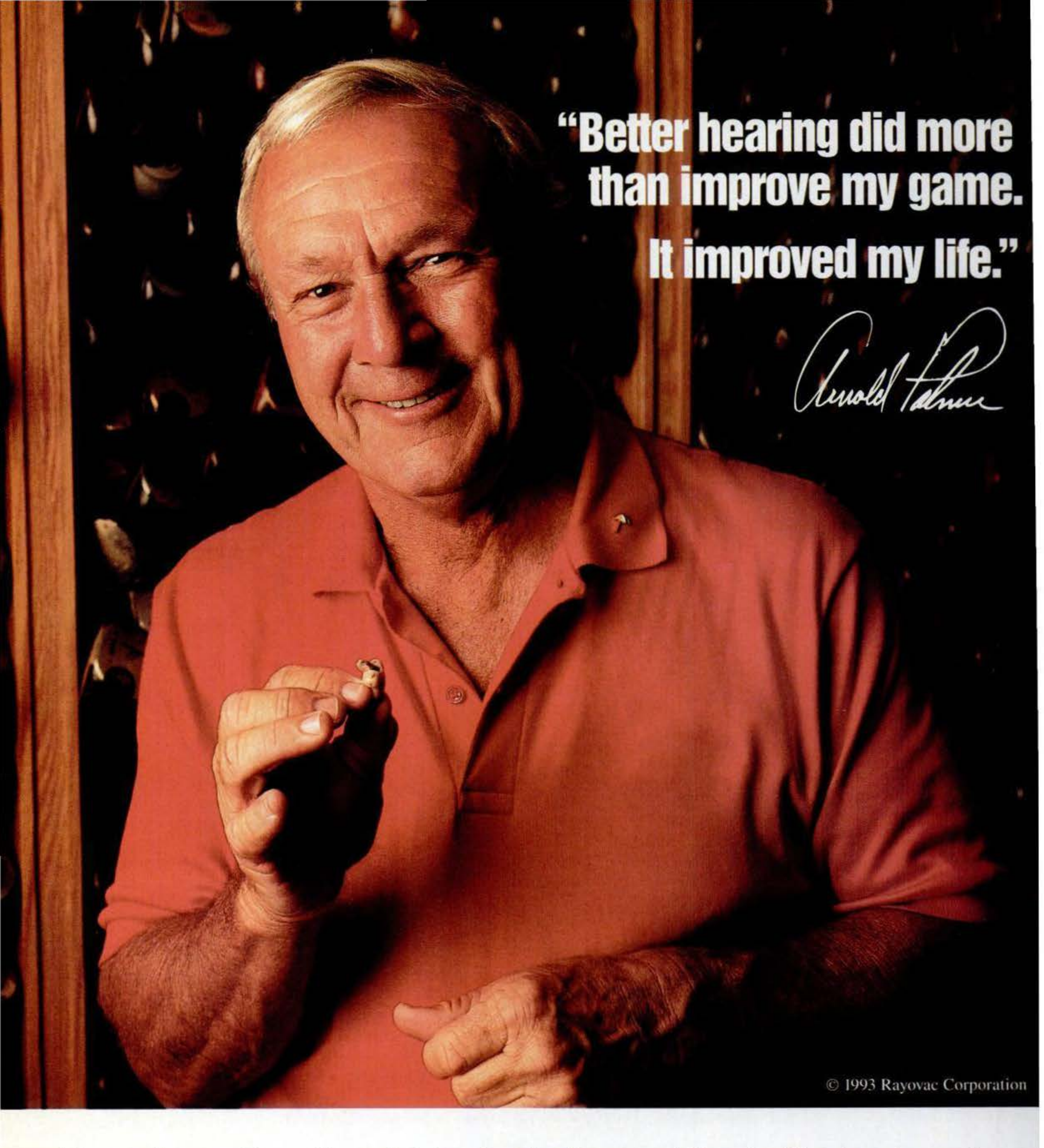

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Popular Science

THE WHAT'S NEW MAGAZINE

JANUARY 1993
Founded in 1872/Vol. 242, No. 1

48 From Russia with wings

Originally constructed and flown in defiance of orders from the KGB, Victor Dmitriev's sophisticated ultralight-aircraft-in-a-suitcase now could be on its way to becoming the hottest new innovation in mini-aircraft. Dmitriev, in partnership with Rienk Ayers of Santa Barbara, Calif., plans to sell the ultralight in kit form.

82 Electric city

Akihabara, the district clustered around the eponymous train station in Tokyo, is the place to see the newest electronics technologies about to sweep the world. The neon neighborhood seems ever on the edge of blowing a fuse.

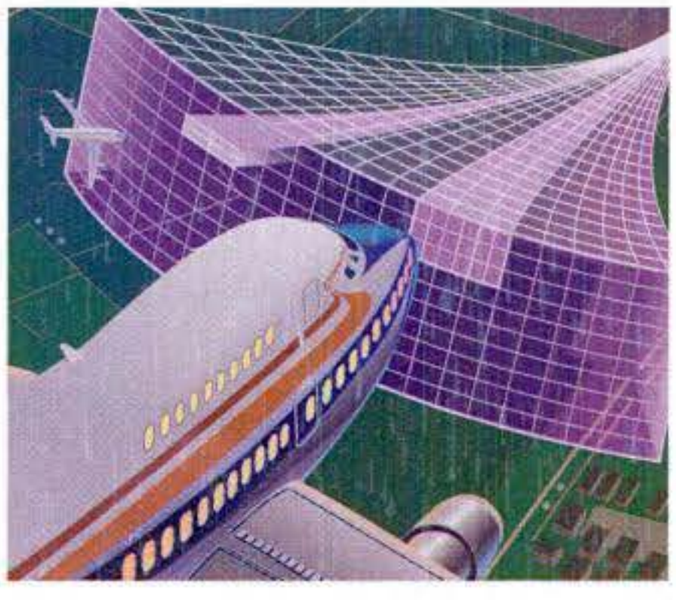
64 Sixes

There's more than one way to hang six cylinders on a crankshaft. Four engine designs set the tone for this test of hot sports coupes: BMW 325is, Ford Probe GT, Subaru SVX, and Volkswagen Corrado.

COVER STORY

76 Fail-safe skies

The Federal Aviation Administration says its new multimillion-dollar computer control system will reduce delays for passengers and virtually eliminate collisions. But critics claim the project, more than a decade in the making, is hopelessly behind schedule.



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COVER BY IAN WORPOLE

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From The Editor

If you hanker to see the world's most extravagant aircraft, the air shows in Paris and Farnborough, England, are for you. But when it comes to the ingenious flying machines of mere mortals, then the place to be is Oshkosh, Wis. Every August it's the site of the annual fly-in of the Experimental Aircraft Association, where all manner of sport, civilian, and recreational aircraft are shown in a county-fair atmosphere.

Last year, the Oshkosh fly-in marked the Western debut of Victor Dmitriev and the X-14d. An ultralight-in-a-suitcase with the aeromechanics of a much larger aircraft, Dmitriev's invention is truly one-of-a-kind. Perhaps as amazing is the story of its development before the fall of the Soviet Union. A former schoolteacher and truck driver with a restless desire to fly, Dmitriev wouldn't let the indirect threats of a repressive government or the direct intervention of the KGB stand in the way of his inventor-entrepreneur instincts. "From Russia with Wings," by freelancer Timothy Gaffney, tells Dmitriev's inspiring story.

For most of us, unfortunately, the story of flight is less adventurous and a lot more tedious than sky-busting in an ultralight. In the crowded commercial skies, takeoff and landing delays plague our schedules, near-miss collisions are too frequent, and recent disasters on or near runways point undeniably to the shortcomings in our air traffic control. For years, the Federal Aviation Administration has been devising a mega-tech answer to the problem of overcrowded airspace. In this month's cover story, Associate Editor Robert Langreth provides an overview of the FAA's grand plan for fail-safe skies.

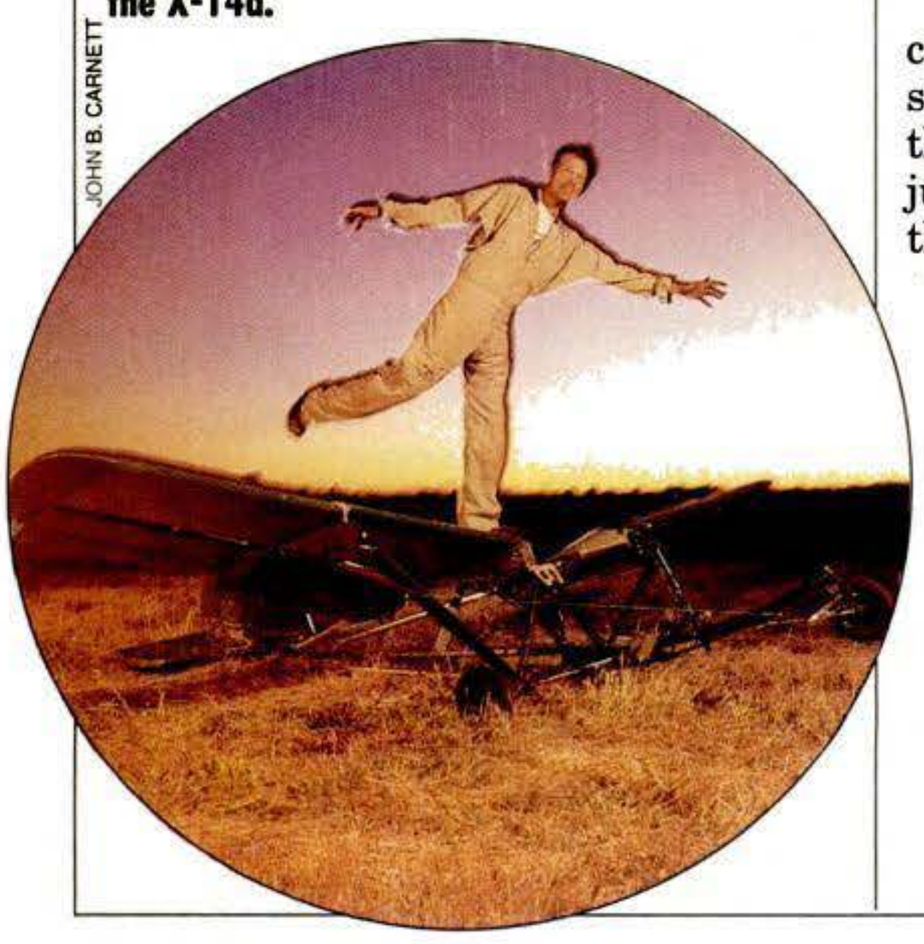
Langreth visited the laboratories where sophisticated equipment such as voice-recognition workstations and artificially intelligent computer software is under development. These high-tech improvements will eventually be used by the tower personnel who direct the comings and goings of airliners carrying millions of passengers each month. For the foreseeable future, though, humans in both the cockpits and the control towers will bear the responsibility for our safety in the skies and on the runways. So it's hard not to root for the FAA to succeed in providing pilots and controllers with the best tools technology has to offer. As one aviation observer told Langreth: "We've been relying on human controllers to be machines, and that is idiotic."

Contributors Mark Uehling and Christopher O'Malley offer two intriguing views of computer security technology in this issue. In the big picture, Uehling investigates the potential weaknesses of our nation's encryption code, designed to safeguard financial transactions, national security, and other electronic communications. Is increasing computer power making obsolete the so-called Data Encryption Standard that our banks and government depend upon? If so, is there a new and better standard available?

Looking back to the near hysteria caused by the Michelangelo virus scare, O'Malley points out that while the damage was slight, the fear was justified. A new generation of viruses threaten our personal computers, and they are more destructive than any we've yet seen. The good news is that computer hardware and software makers are working on new ways to combat these stealthy threats.

Inventor Victor Dmitriev steps ultralightly on the X-14d.

JOHN B. CARNETT



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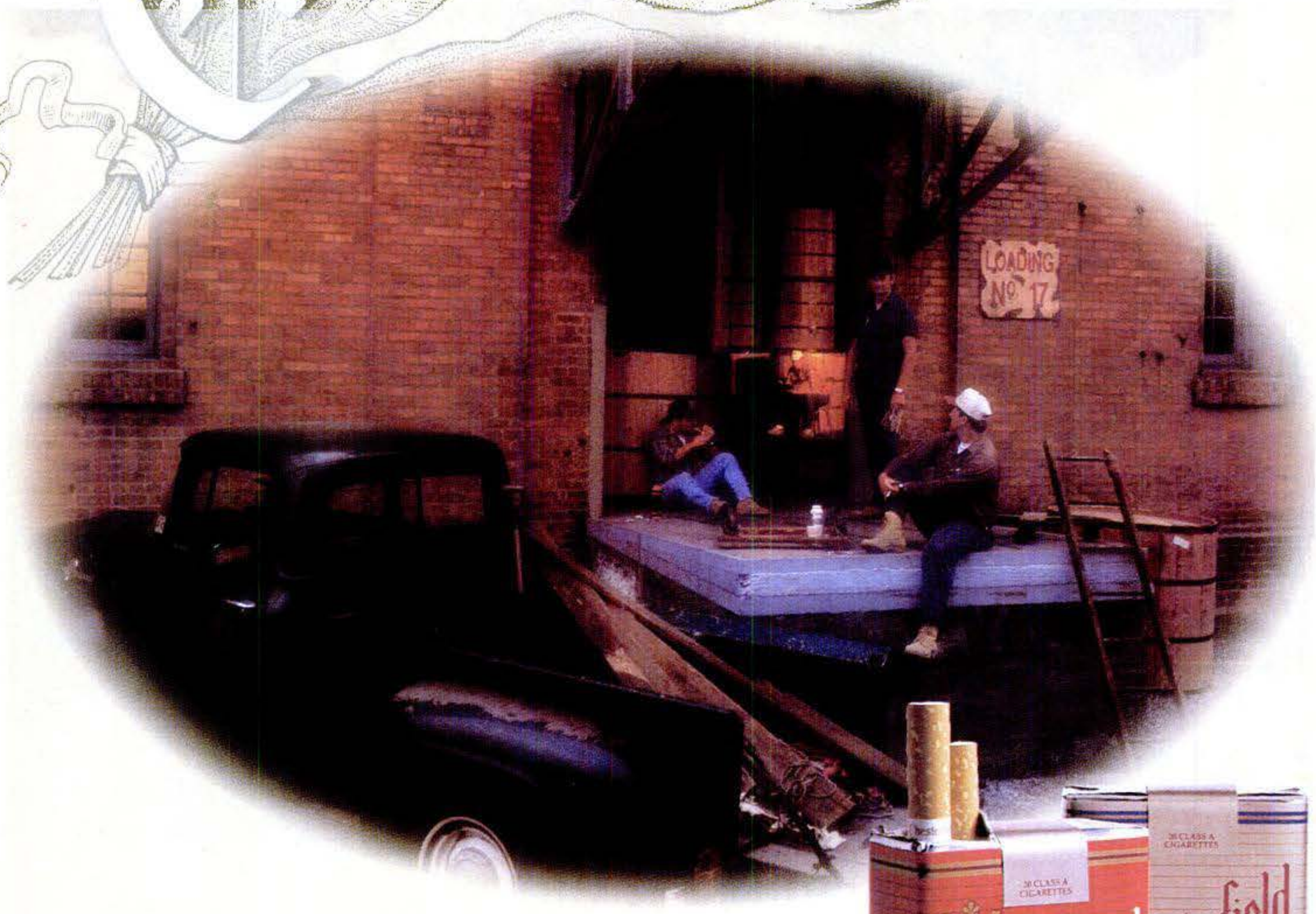

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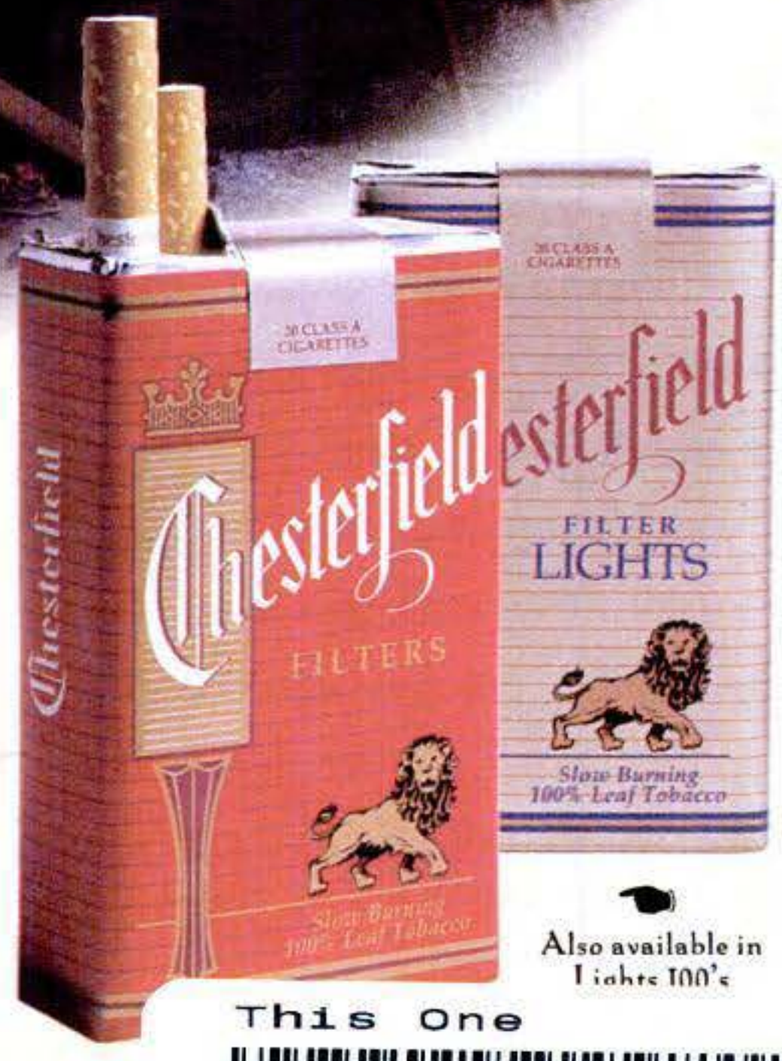

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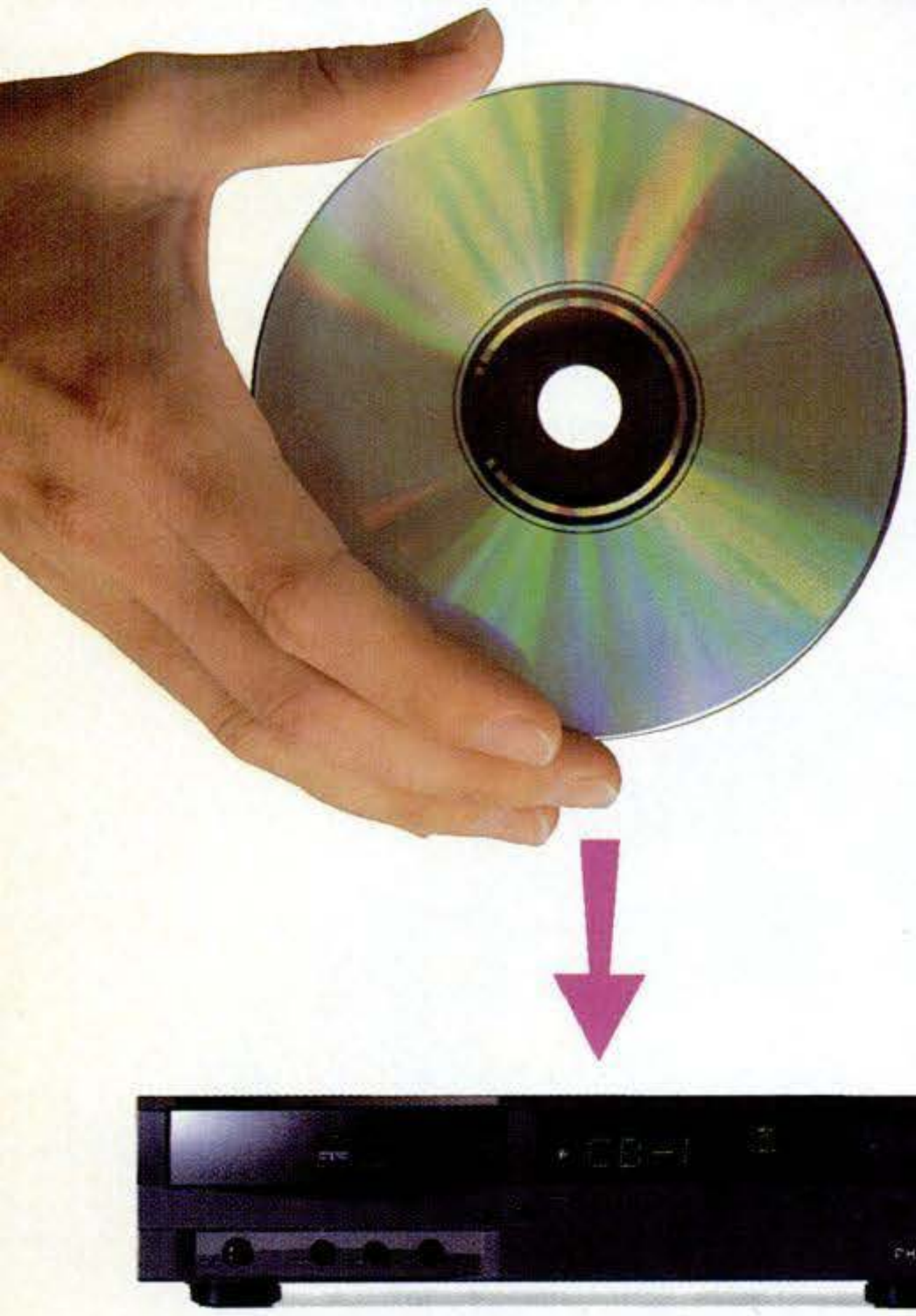

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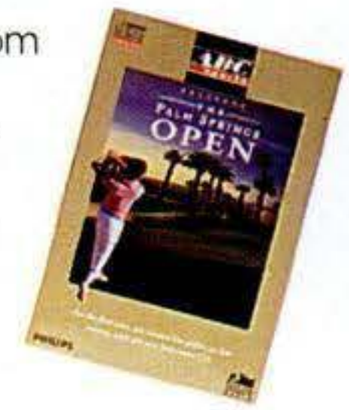

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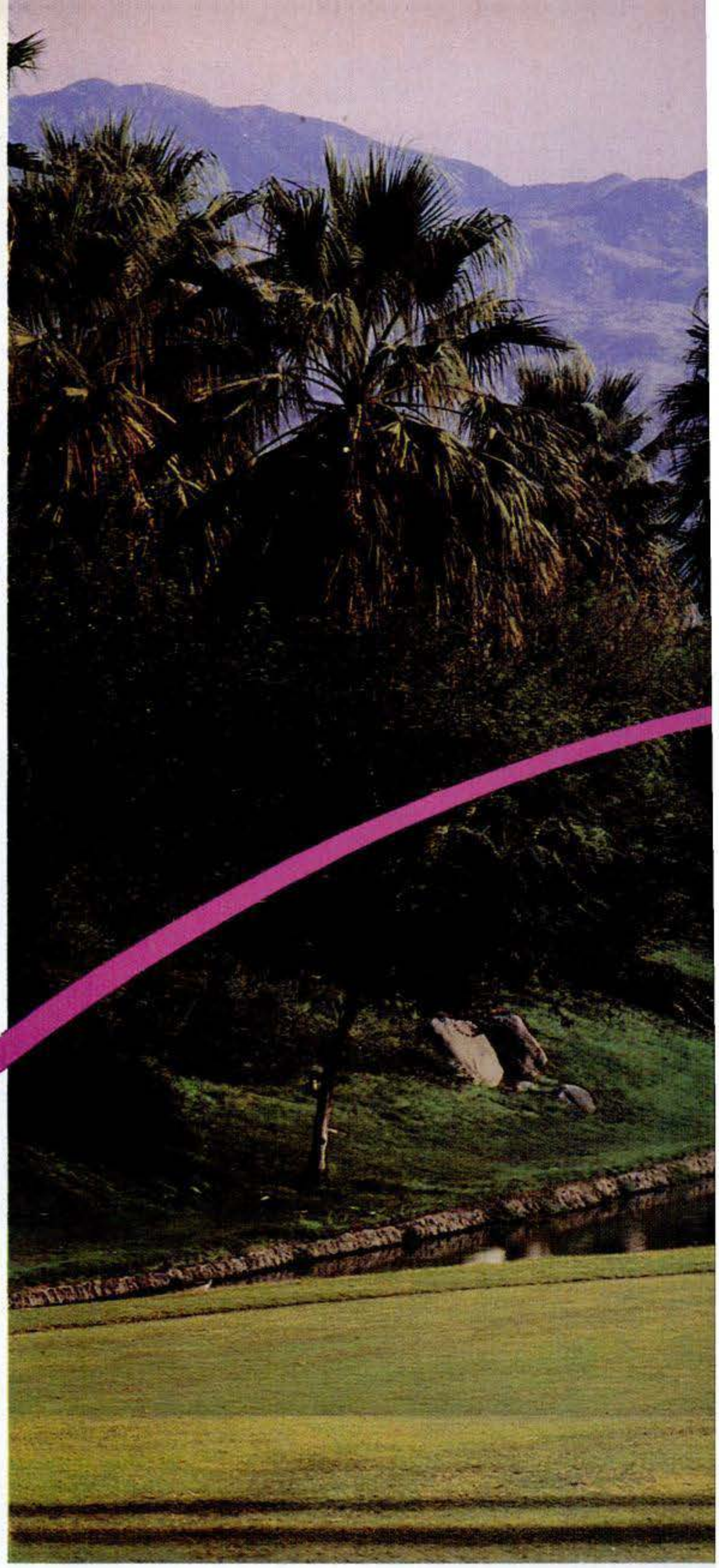

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But this is only one of the many titles available. Major publishers already involved in the production of CD-I discs include

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Readers Talk Back

Foundation frustrations

Regarding frost-protected shallow foundations ["Home Newsfront," Aug. '92]: In the mid '70s, I began to research insulated foundations, superinsulation, and radiant-slab heat systems. I discovered a lack of technical literature and so experimented on my own, particularly with foundation design. There are some inherent problems in this type of construction: The installation method and quality is critical; landscaping close to the house is difficult in 10 to 12 inches of soil; and realtors and appraisers have pointed out that the lack of a basement can lower the resale value of the home.

Ernest N. Smalley, President
Smalley Co., Rutland, Vt.

In your article on shallow foundations, your illustration caption identifies the frost-protected shallow foundation as being new to the United States. Sorry! Frank Lloyd Wright describes the use of a drywall footing in the building of Taliesin North, about 1902, which is identical—other than the polystyrene insulation—to that in your article. Wright identified the same savings in building costs and the same problem with acceptance by building departments. Let's hope that 90 years after Wright's observations, this cost-saving approach is finally incorporated into our model building codes.

Phillip J. Keuhlen, Mukilteo, Wash.

COURTESY FRANK LLOYD WRIGHT FOUNDATION

Architect Frank Lloyd Wright pioneered the modern use of frost-free shallow foundations in this house, built around 1902.

Techniques for building frost-resistant shallow bearing walls have been around since the Stone Age. The Taliesin building's foundation is typical of early drywall footing. Wright updated the technology in the 1930s when he started building his Usonian houses on monolithic, heated slabs placed over beds of free-draining gravel. The Scandavavians simply took Wright's idea and spent the next 30 years refining it.—Charles Wardell

A concrete solution

After World War II, a close friend, F. O. Walker, established the company Intrusion Prepact. It specialized in stabilizing bridge pilings, buildings, and other structures that had become destabilized due to changing soil conditions ["Science Newsfront," Aug. '92]. Some structures were jacked back up to their original levels by pumping liquid concrete under high hydraulic pressure into specific soil layers beneath these structures. Could this technology stabilize the Leaning Tower of Pisa?

Leo Toussaint, Miami, Fla.

This idea has been proposed, but the concrete pumping process could overstress the tower.—Dawn Stover

Electric glow?

External burning may be one explanation for the observed glow of high-speed high-altitude aircraft ["Science Newsfront," Sept. '92]. But a more probable explanation is a revival of very low aerodynamic drag aircraft that were built in the 1950s using electric charge streamlining (ECS). Specially constructed leading surfaces discharge electricity into the air ahead of the plane, and the plane's skin maintains the same charge as that in the air. As the plane enters the charged air, the air is repelled by the plane's surfaces. The size and weight of the electric generators that create the charges made ECS planes impractical. But with recent advances in high-temperature superconducting materials and their use in compact electric-power-generating devices, such aircraft could be possible today.

Joe Egan, Summerville, S.C.

Correction: Each of the Spectroscopic Survey Telescope's 85 mirrors has a diameter of 40 inches ["What's New," Oct. '92].

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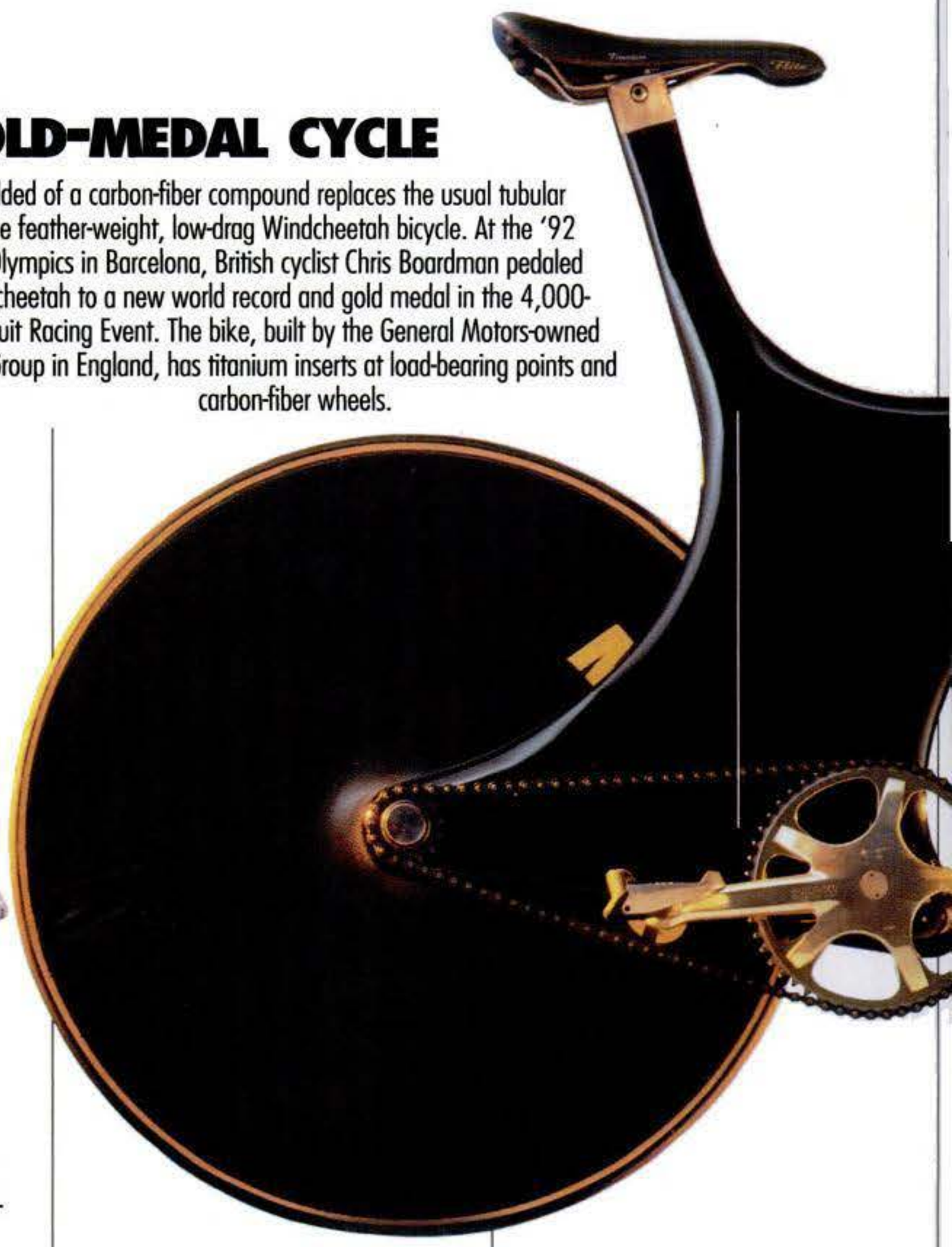
WHAT'S NEW

EDITED BY MARCELLE M. SOVIERO AND JUDITH ANNE YEAPLE

POWERFUL PC

Poised to support the next generation of PC software, the Sensation! from Tandy integrates multimedia capabilities with a 486-based IBM-compatible PC. The computer features a CD-ROM drive, 107-megabyte hard drive, an enhanced soundboard with an FM synthesizer, a Multimedia Palette Chip that supports 16 million colors, and a modem with voice-mail capabilities. Price: $1,999.



GOLD-MEDAL CYCLE

A body molded of a carbon-fiber compound replaces the usual tubular frame in the feather-weight, low-drag Windcheetah bicycle. At the '92 Summer Olympics in Barcelona, British cyclist Chris Boardman pedaled the Windcheetah to a new world record and gold medal in the 4,000-meter Pursuit Racing Event. The bike, built by the General Motors-owned Lotus Group in England, has titanium inserts at load-bearing points and carbon-fiber wheels.

PICKUP PREVIEW

Dodge's new full-size Ram pickup will be available in 1/2-, 3/4-, and 1-ton models, in both two- and four-wheel-drive. The 1994 model will feature a new V10 engine derived from the current series of V8 engines.

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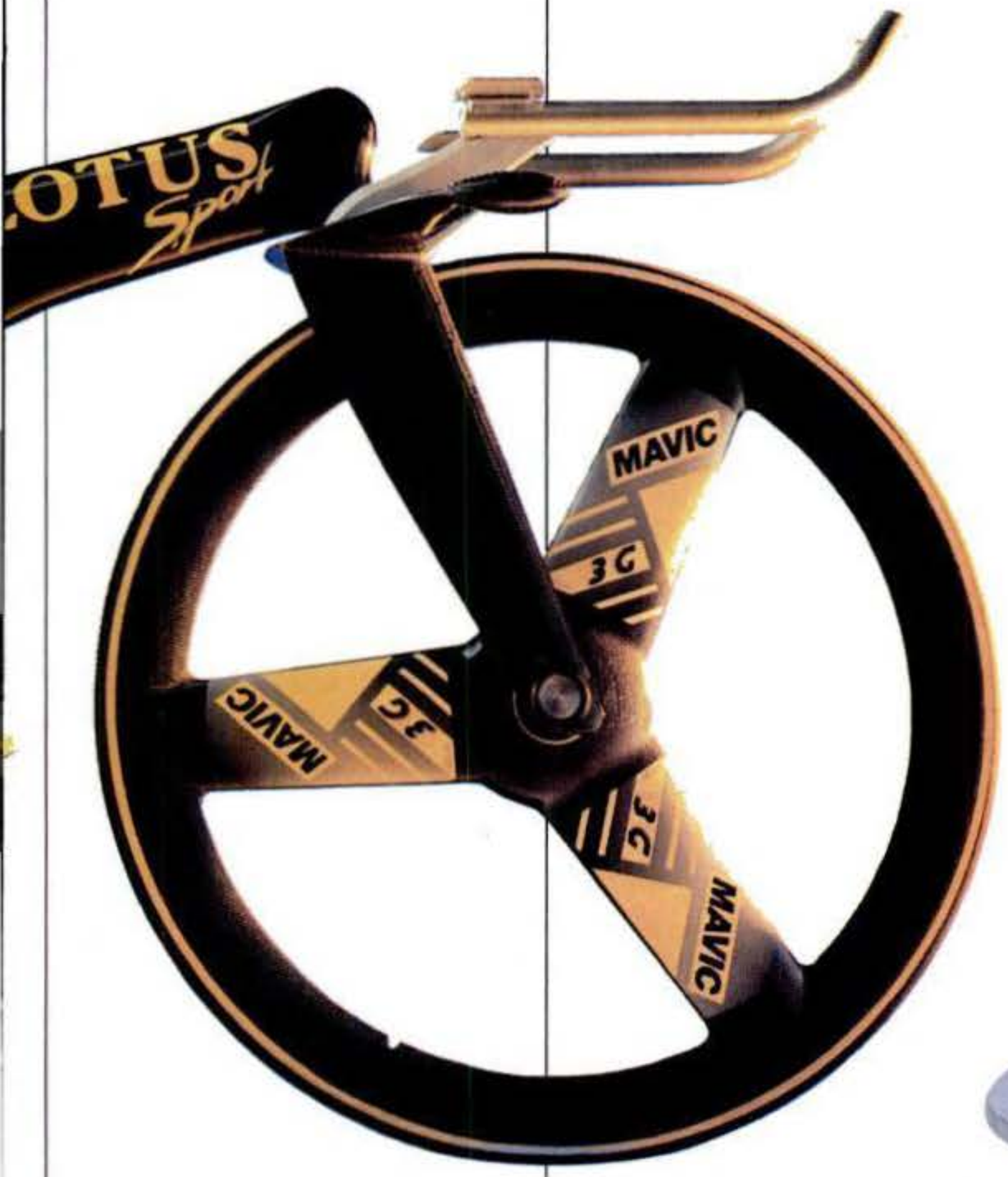
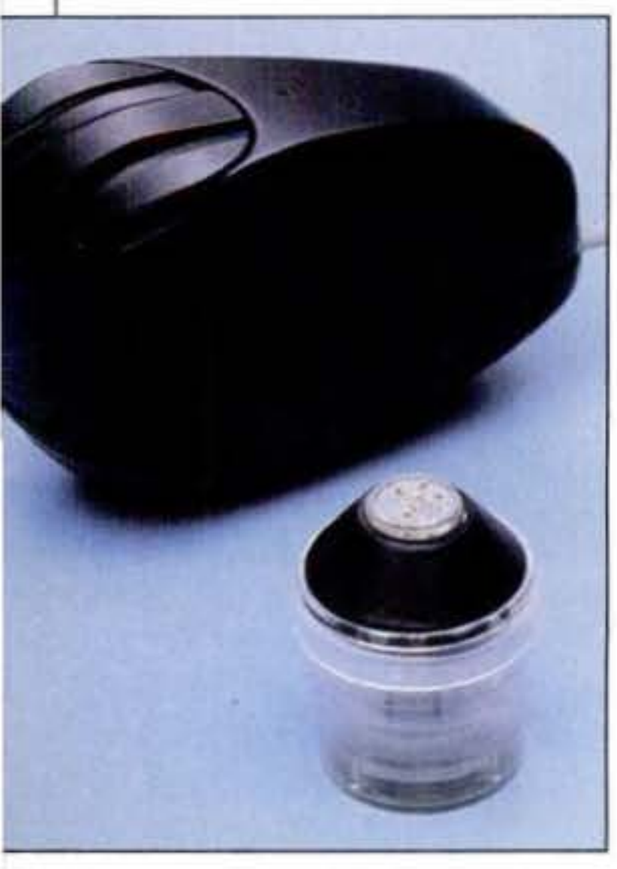
MICRO "PHONE"

The Norris Ear Phone, a miniature hands-free microphone that uses bone-conduction technology to transmit and receive vocal vibrations, fits in the ear like a hearing aid. A $100 tethered version that attaches to a single-line phone or modem is now available; a wireless model is expected later this year. Norris Communications Corp., 12800 Brookprinter Place, Poway CA 92064.





FREE-RANGE MOUSE

Unlike a conventional computer mouse that's rolled along a surface, the hand-held GyroPoint operates freely in the air. Using Gyro Engine technology, the six-ounce device follows your movements to manipulate three-dimensional computer images or control multimedia presentations. The GyroPoint costs about $700; a wireless version is about $1,000. Gyration Inc., 12930 Saratoga Ave., Building C, Saratoga CA 95070.

POWER FINS

Unlike conventional diving fins, Force Fins are flexible and V-shaped to make the legs' natural two-stroke kick more efficient. The result is about 40 percent more aerobic efficiency, meaning less fatigue, and 50 percent more thrust. The polyurethane fins cost between $70 and $90, and are available in assorted colors. Force Fin, 28 Anacapa St., Santa Barbara CA 93101.

SPACE-STYLED BBQ

The Thermos Thermal Electric Grill combines an innovative design with energy-saving features. The double-walled metal dome is insulated to trap heat, and the design of the nonstick grilling surface helps eliminate "hot spots" associated with gas or charcoal barbecues. Price: about $300. The Thermos Co., 300 N. Martingale Rd., Suite 200, Schaumburg IL 60173.

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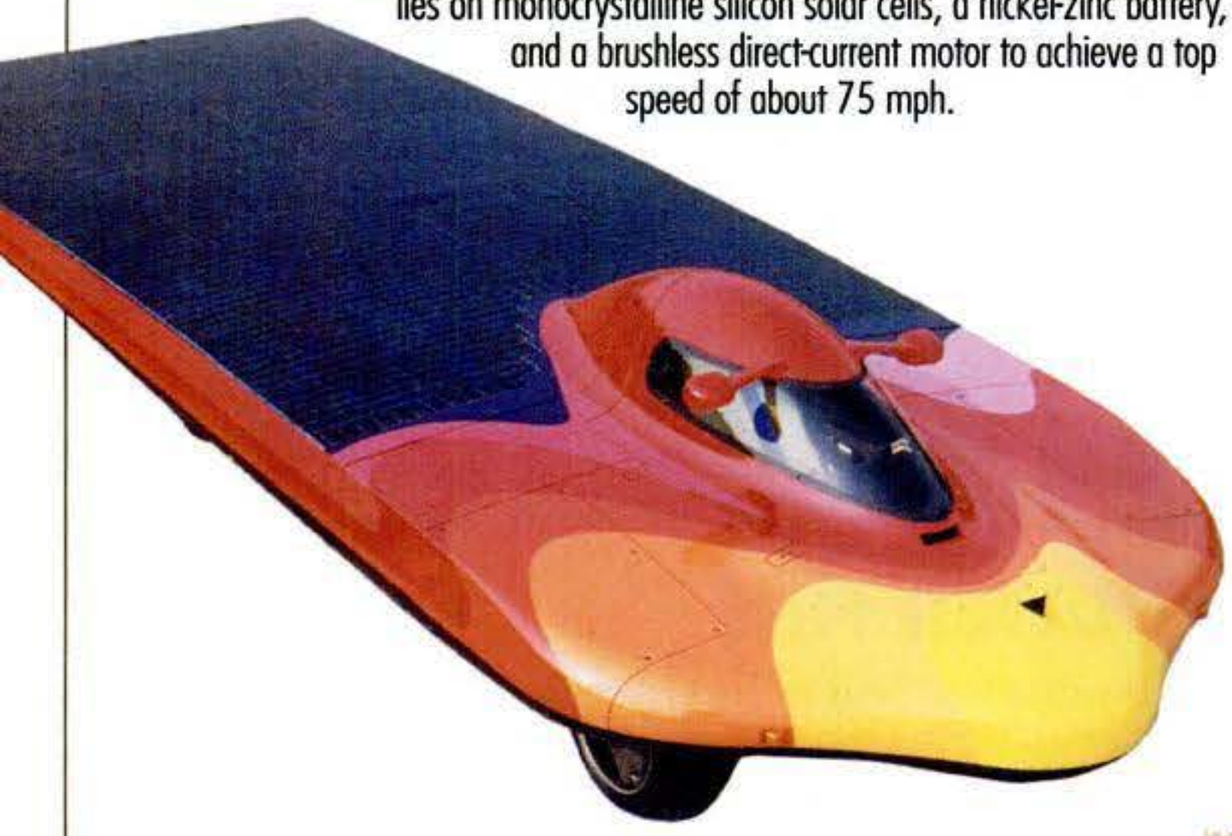
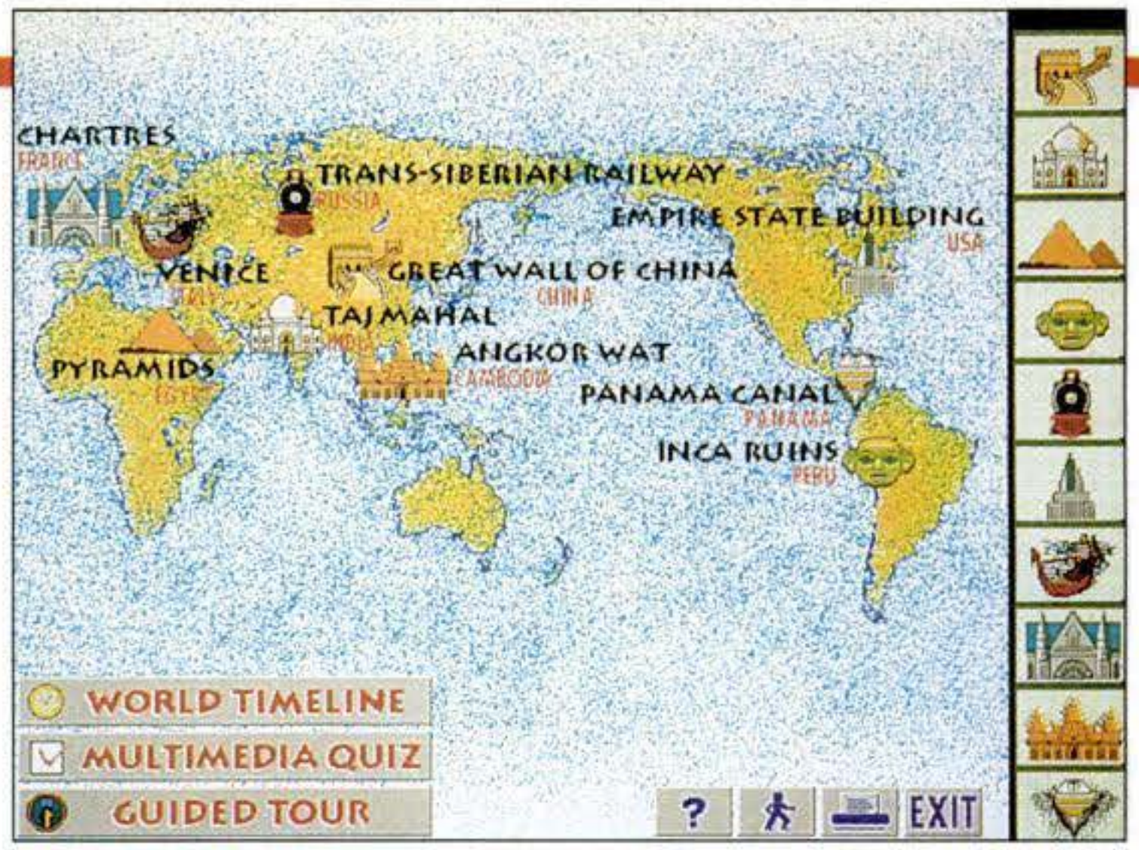
WHAT'S NEW

RaRa encore

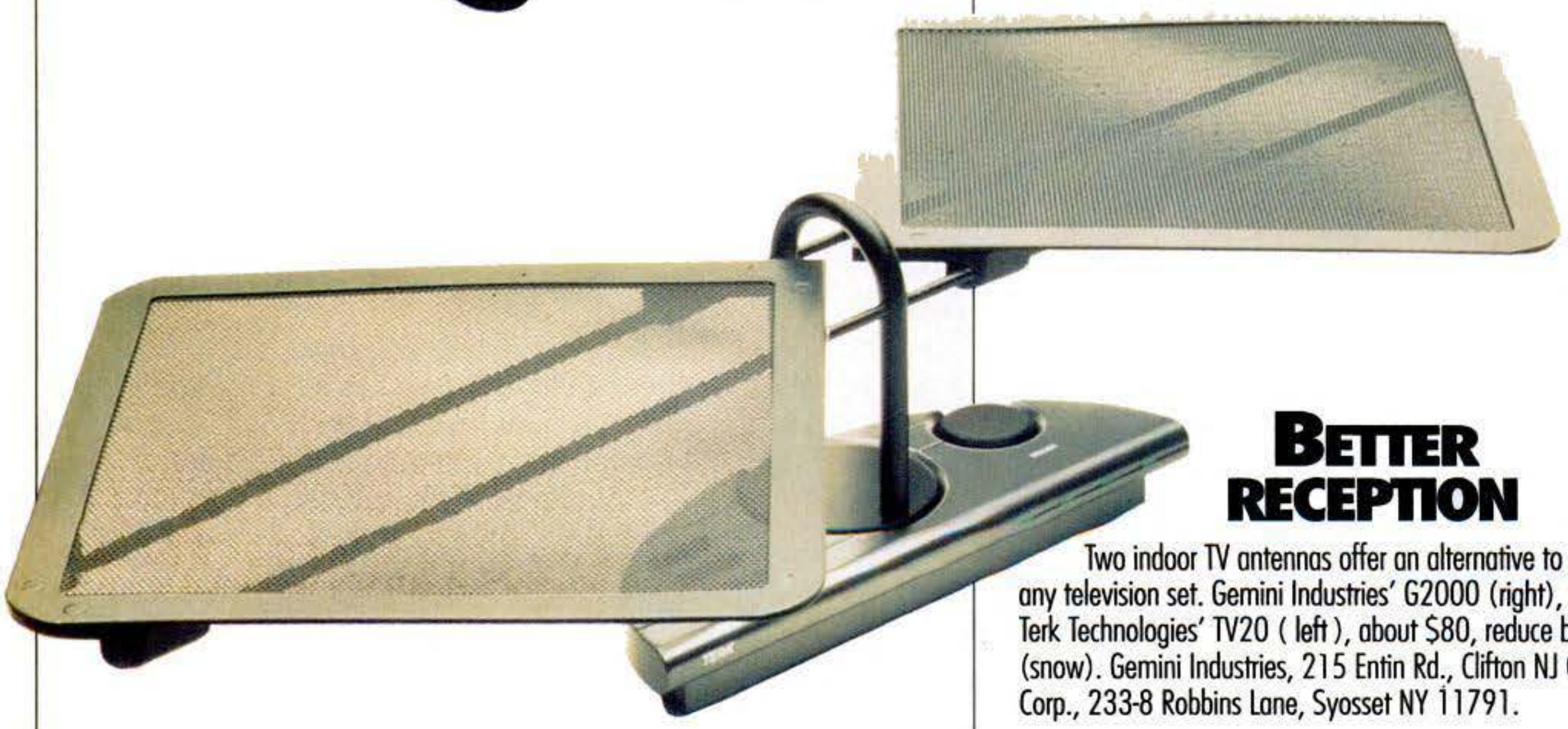
Toyota's newest entry on the solar-car rally circuit is the RaRa 10, a successor to the RaRa II solar demonstration vehicle ["What's New," March '91]. The car relies on monocrystalline silicon solar cells, a nickel-zinc battery, and a brushless direct-current motor to achieve a top speed of about 75 mph.





Travel, PC style

Great Wonders of the World Manmade Wonders explores the history, architecture, and legends of such marvels as the Taj Mahal and the Great Wall of China. The $80 CD-ROM program contains 200 full-screen photos, 100 maps, 30 animation sequences, and 40 minutes of motion video. InterOptica Publishing, 300 Montgomery St., San Francisco CA 94104.

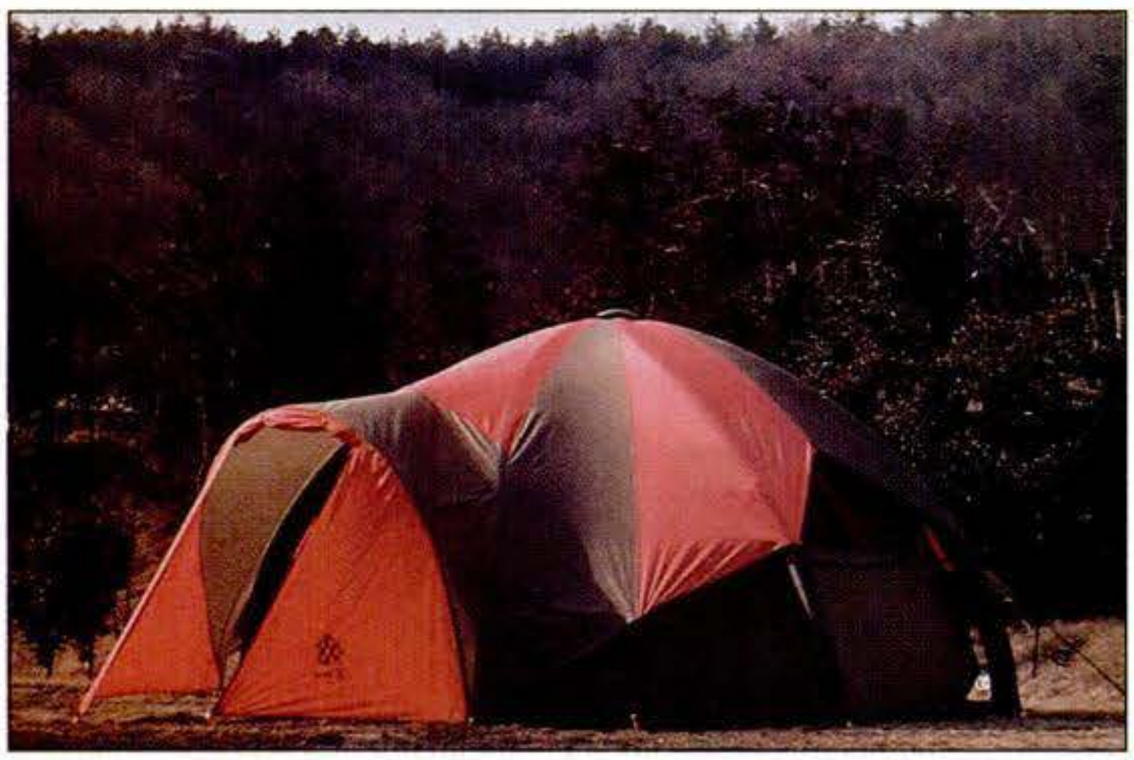


Better reception

Two indoor TV antennas offer an alternative to cable hookups and work with any television set. Gemini Industries' G2000 (right), from $50 to $60, and Terk Technologies' TV20 (left), about $80, reduce both ghosting and video noise (snow). Gemini Industries, 215 Entin Rd., Clifton NJ 07014. Terk Technologies Corp., 233-8 Robbins Lane, Syosset NY 11791.

Pumped-up tent

Mobi Air Cottage inflatable tents from Tokyo Tire & Rubber are pumped up with air in five minutes with a blower that connects to a car battery. The large model has 220 square feet of floor space and costs about $2,690; a $1,925 version covers 129 square feet. The tents are available in Japan, and both include the blower.



Desktop display

Images-4U is a palm-size liquid-crystal-display panel that functions as a moving message board. The $139 device accommodates messages up to 900 characters in length, which can be programmed with a paper-thin detachable keyboard. Microspectrum Technologies, Box 133, Oak Park IL 60304.

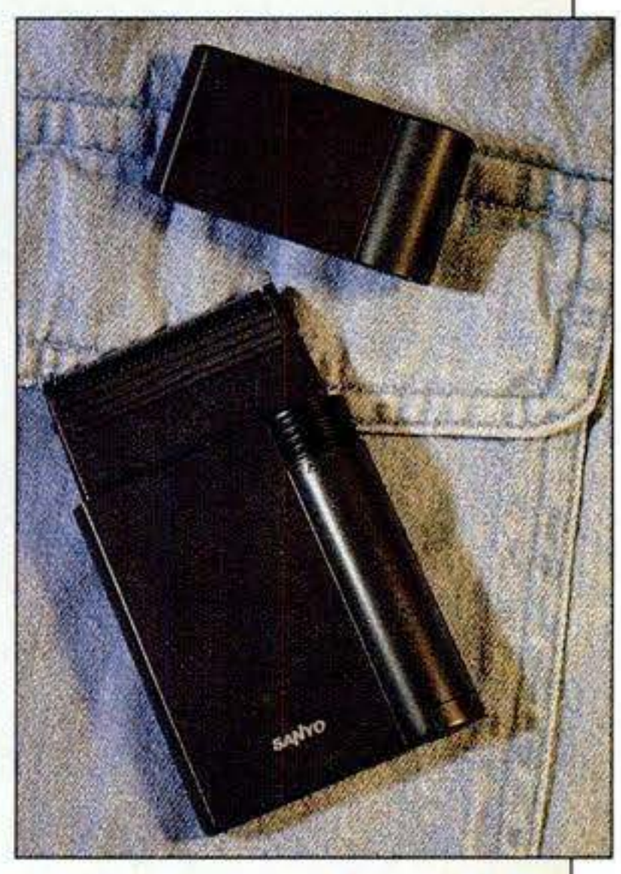
Copyrighted material

MICRO SIZE, MACRO SOUND

Sharp's CD-Q10 microcomponent stereo system is one-third the size of the company's mini-component systems, measuring roughly six inches wide by seven inches high—or just large enough to accommodate a compact disc. An artificial intelligence editing feature automatically selects CD titles to suit the tape length when recording. Price: $900.

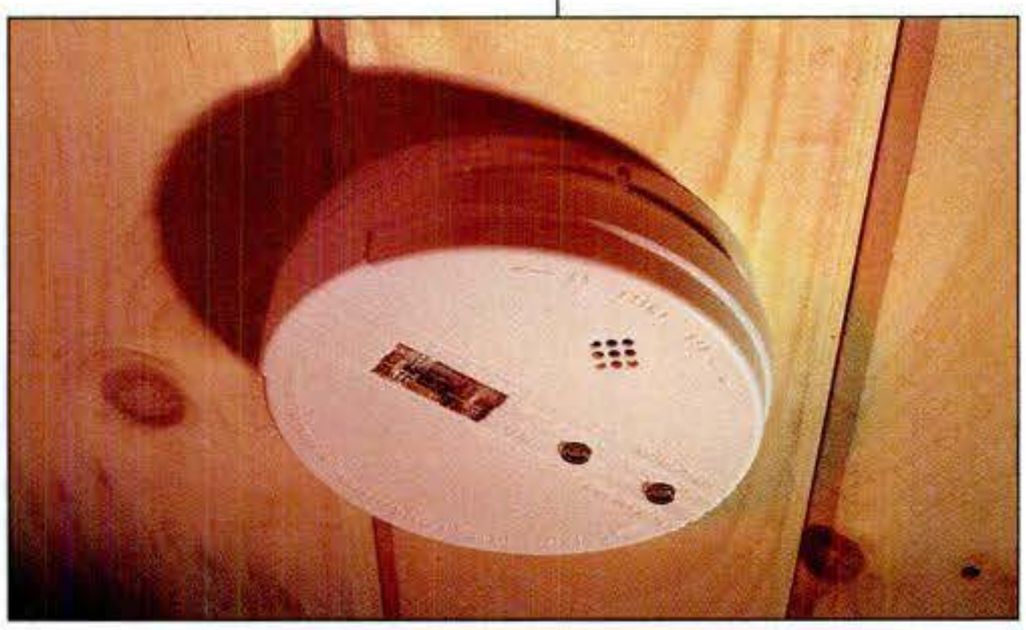
SPACE-SAVING SHAVER

About the size of a credit card, Sanyo's SV-P700 electric shaver runs for 40 minutes on one alkaline battery or for about 25 minutes with a rechargeable nickel-cadmium battery. The $70 shaver comes with a case and cleaning brush.



WORKOUT WATERCRAFT

Similar to a recumbent bicycle but with arm levers that can be used for additional "pedaling" power (and a full-body workout), the 11-foot-long human-powered Aquatilis watercraft has a top speed of ten mph. To steer, the pilot leans his upper body from side to side in the seat back, which moves the last three feet of the segmented pontoons left or right. Price: less than $2,000. EcoSports America, 179 H St. Petaluma CA 94952.



LIGHTED ALARM

The light on this innovative smoke alarm flashes when the alarm sounds or when the battery needs replacing. A "hush" button enables you to temporarily silence false alarms triggered by smoke from cooking or cigarettes. Price: $17 to $24. Fyrnetics, Inc., 1055 Stevenson Ct., Suite 102W, Roselle IL 60172.

BIG, SPORTY BIMMER

The 1993 BMW 850CSi luxury sports coupe boasts a 12-cylinder, 5.6-liter engine with a six-speed manual transmission and a sporty low-slung suspension. It has a top speed of 155 mph. Available in Europe, the car is about $100,000.

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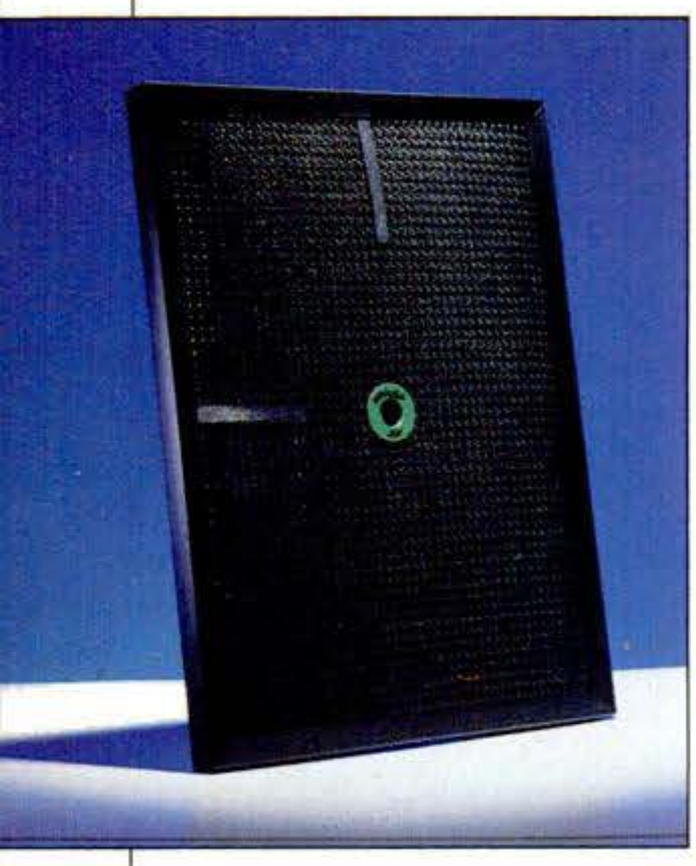
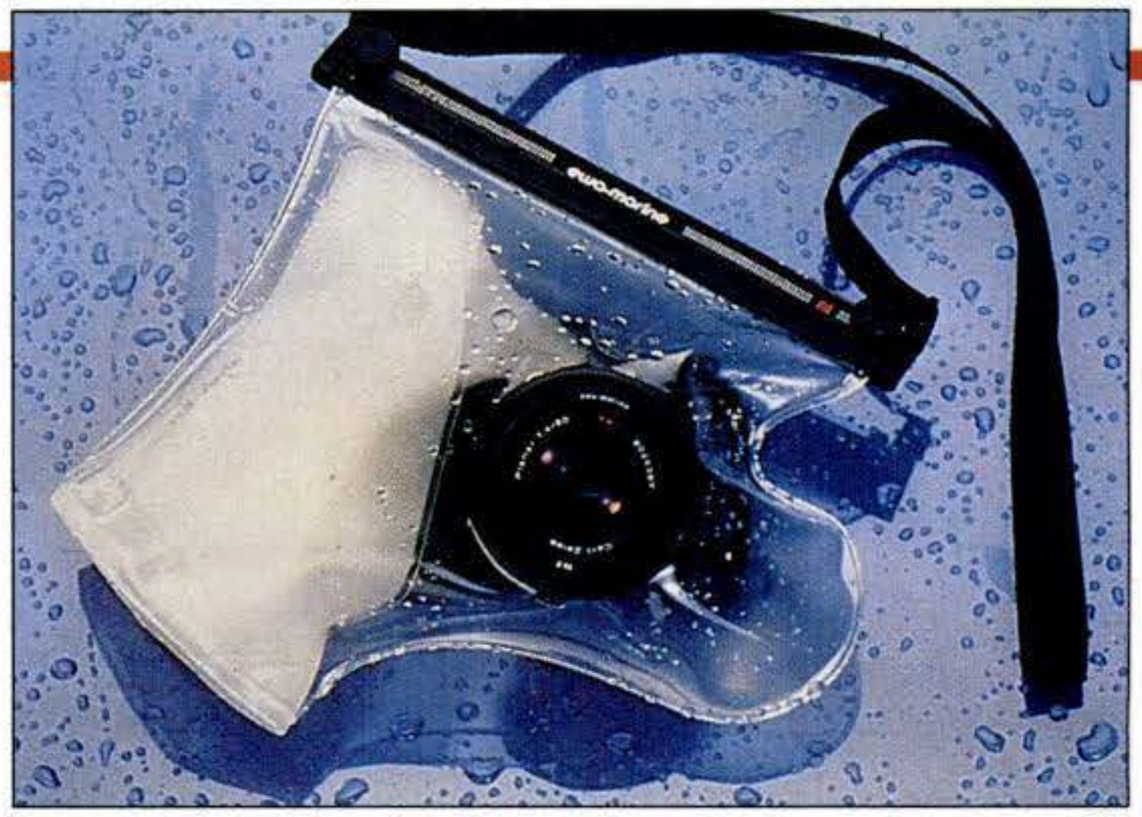
WHAT'S NEW



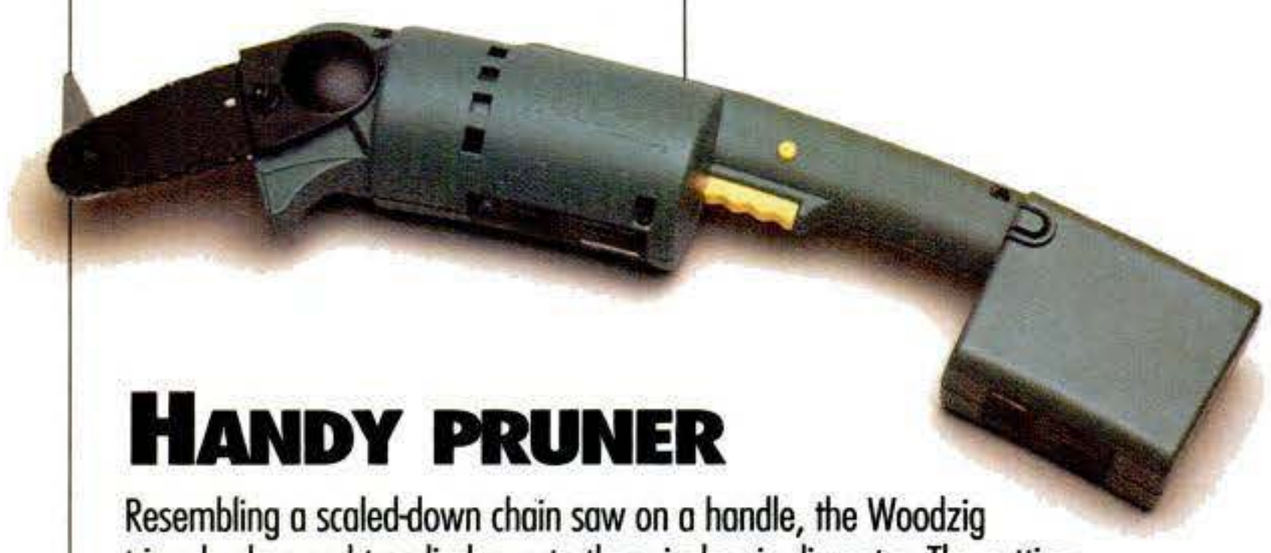
WHISTLING FILTER

When this air filter needs cleaning, it whistles a warning. An EPA-approved antimicrobial agent is also injected into the Whistle-Air Electrostatic Air Filter to inhibit the growth of bacteria, fungi, and mold. Price: $60. Newton Product Co., 3874 Virginia Ave., Box 27175, Cincinnati OH 45227-0175.



SLR WETSUIT

Ewa Marine's Master Series of flexible, airtight housings protect manual-focus SLR cameras underwater or in the sand. The casings feature a built-in glove for fingertip control and an adapter ring that holds the camera securely to the front optical glass port. Prices range from $189 to $219 for five models.



HANDY PRUNER

Resembling a scaled-down chain saw on a handle, the Woodzig trims bushes and tree limbs up to three inches in diameter. The cutting cassette adjusts the tension of the chain during use; replacement cassettes are available. Woodzig tools come in a 13.2-volt battery-powered version (about $110) or a 110-volt corded version (about $70). Oregon Cutting Systems, Box 22127, 4909 S.E. International Way, Portland OR 97222-0080.

PHONE SCRAMBLER

AT&T's 1.5-pound portable encryption device for standard telephones scrambles conversations so others can't listen in (see "Cracking the Code," this issue). Audio signals are converted to a stream of data that requires a second security device on the receiving phone for decryption. Each Model 3600 scrambler is about the size of a hand-held calculator and costs $1,195.

WHITE-HOT WHEELER

The British-built Scorpion, a three-wheeled concept car, has a BMW K1 1,100cc, four-cylinder, 16-valve engine complete with drive shaft and swing-arm rear suspension. Its space-frame chassis has a MacPherson-type front suspension with ventilated disc brakes. Able to reach 60 mph in five seconds, the 110-hp Scorpion has a top speed of 135 mph and sells for about $20,000 in England.

POWER-SURGE PROTECTION

The Traveler TVSS (Transient Voltage Surge Suppression) unit protects your phone and computer equipment from power problems while you're on the road. The $150 device measures 4 by 7.25 by 1.7 inches so it stows neatly in your briefcase. DSK Inc., 538 S. 1400 W., Orem UT 84058.

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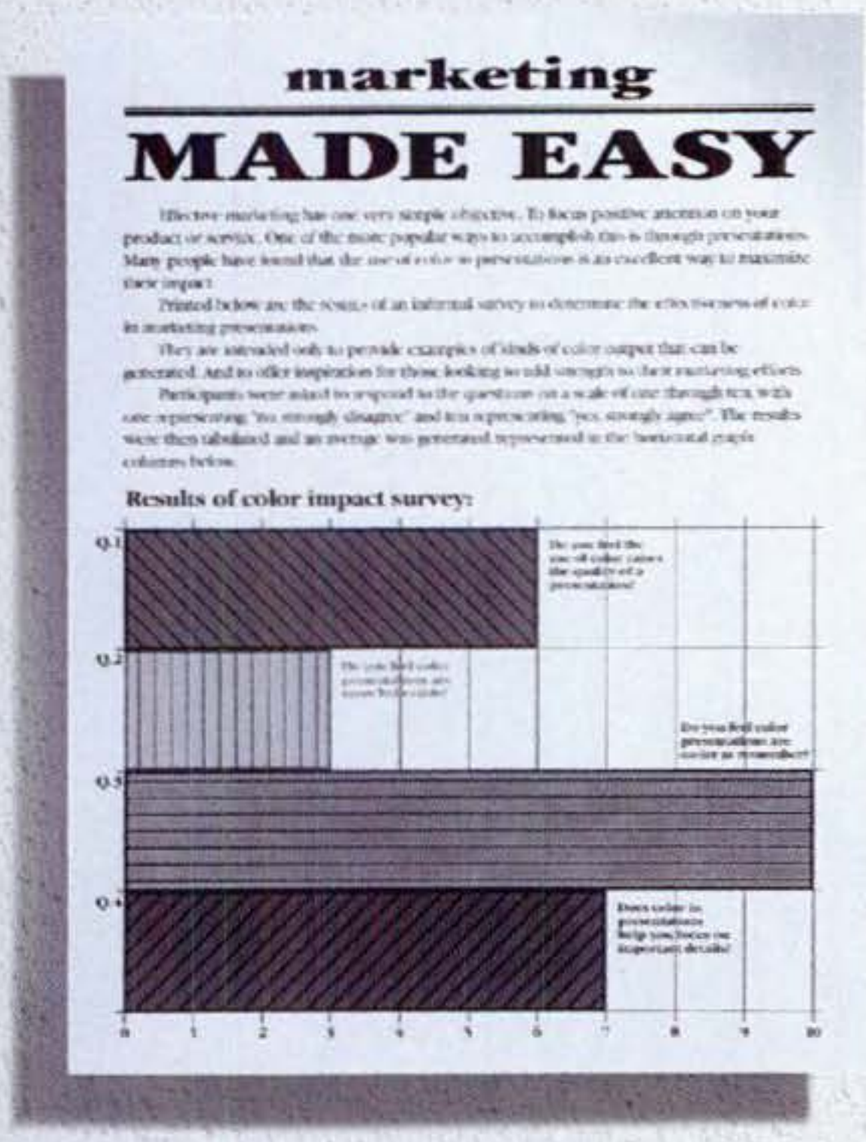
Make it clear.



marketing

MADE EASY

Effective marketing has one very simple objective. To focus positive attention on your product or service. One of the most popular ways to accomplish this is through presentations. Many people have found that the use of color in presentations is an excellent way to maximize their impact.

Printed below are the results of an informal survey to determine the effectiveness of color in marketing presentations.

They are intended only to provide examples of kinds of color output that can be generated. And to offer inspiration for those looking to add strength to their marketing efforts.

Participants were asked to respond to the questions on a scale of one through ten, with one representing "no, strongly disagree" and ten representing "yes, strongly agree". The results were then tabulated and an average was generated, represented in the horizontal graph columns below.

Results of color impact survey:

Q.1
Do you find the use of color colors the quality of a presentation?
Q.2
Do you find color presentations are easier to remember?
Q.3
Does color in presentations help you/focus on important details?
0 1 2 3 4 5 6 7 8 9 10

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Make it colorful.

And color.

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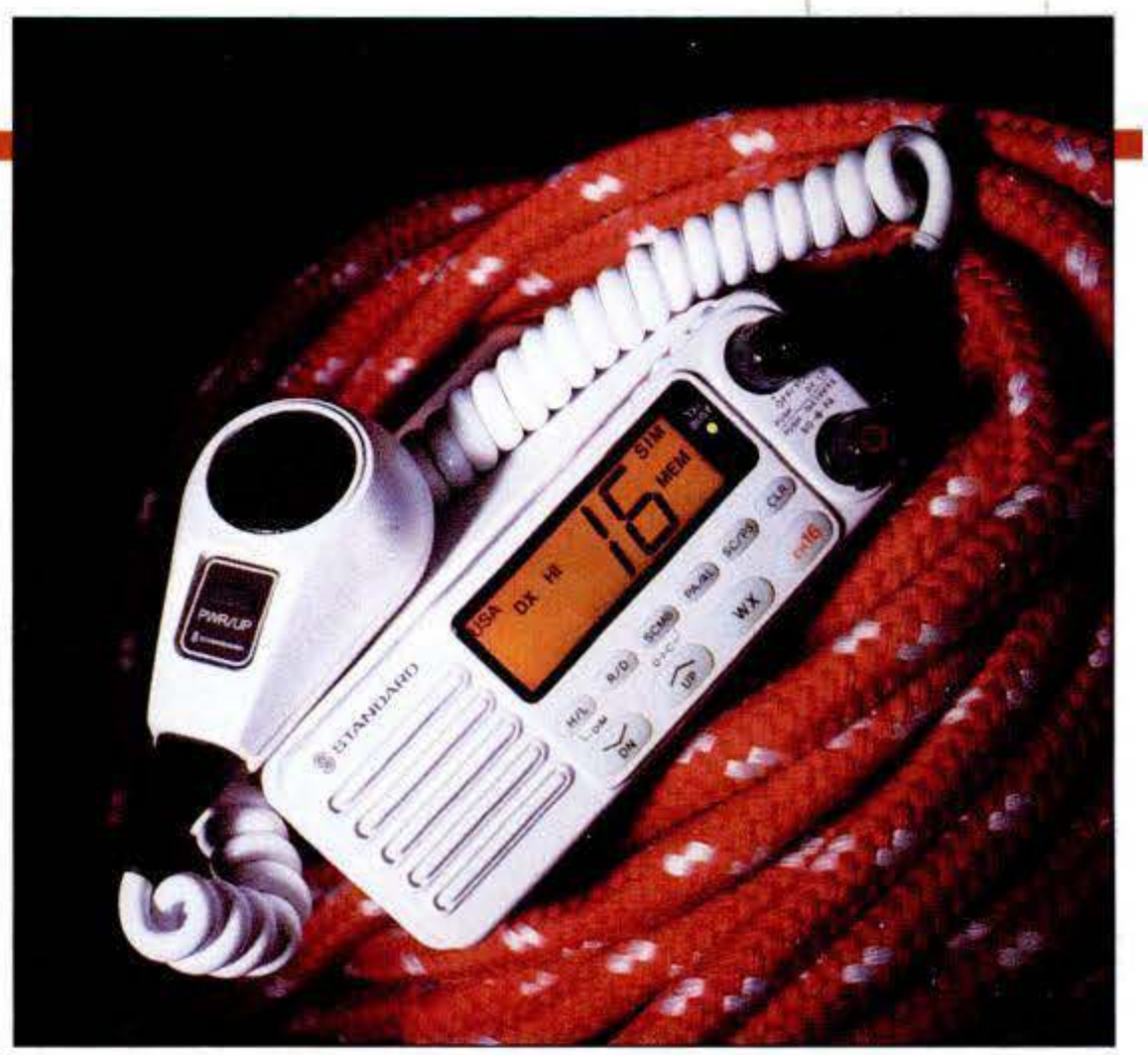
WHAT'S NEW

COMPOSITE SPANS

Prestek bridges can be assembled and installed without heavy machinery, making them suitable for parks and other ecologically fragile environments. Made of fiberglass and Kevlar aramid fiber, the bridges can be used as walkways, roadways, or as handicapped-access ramps. E.T. Techtonics, 2117 Tryon St., Philadelphia PA 19146.



SAFETY RADIO

The Horizon Omni marine radio accepts a signal from the National Oceanographic and Atmospheric Administration alerting you to tune to the weather channel for emergency broadcasts. When connected to a position receiver, the $699 radio also sends a continuous call for help with your exact location to the Coast Guard. Standard Communications Corp., Box 92151, Los Angeles CA 90009-2151.

ROBOT HUMVEE

This unmanned military Humvee uses cameras to follow lane markings to predetermined destinations. The vehicle uses computer software developed by the National Institute of Standards and Technology to control steering, braking, fuel supply, and surveillance equipment. Still partially controlled by a remote operator, the Humvee someday may be completely automated for use in convoys.

CD STORAGE SLEEVES

Storage space a problem? These compact-disc holders can adapt to fit in any area you have. Each Music Block sleeve holds one CD and interlocks both vertically and horizontally with other blocks. A box of ten costs $8. RFL Products, 810 Wyndham Hills Dr., Lexington KY 40514.

WIRELESS WONDER

Recoton's W400 Wireless Stereo Speaker system transmits music up to 100 feet from the source. Unlike infrared systems that rely on line of sight, the W400's radio frequency signal travels through walls and floors. Price: $130.

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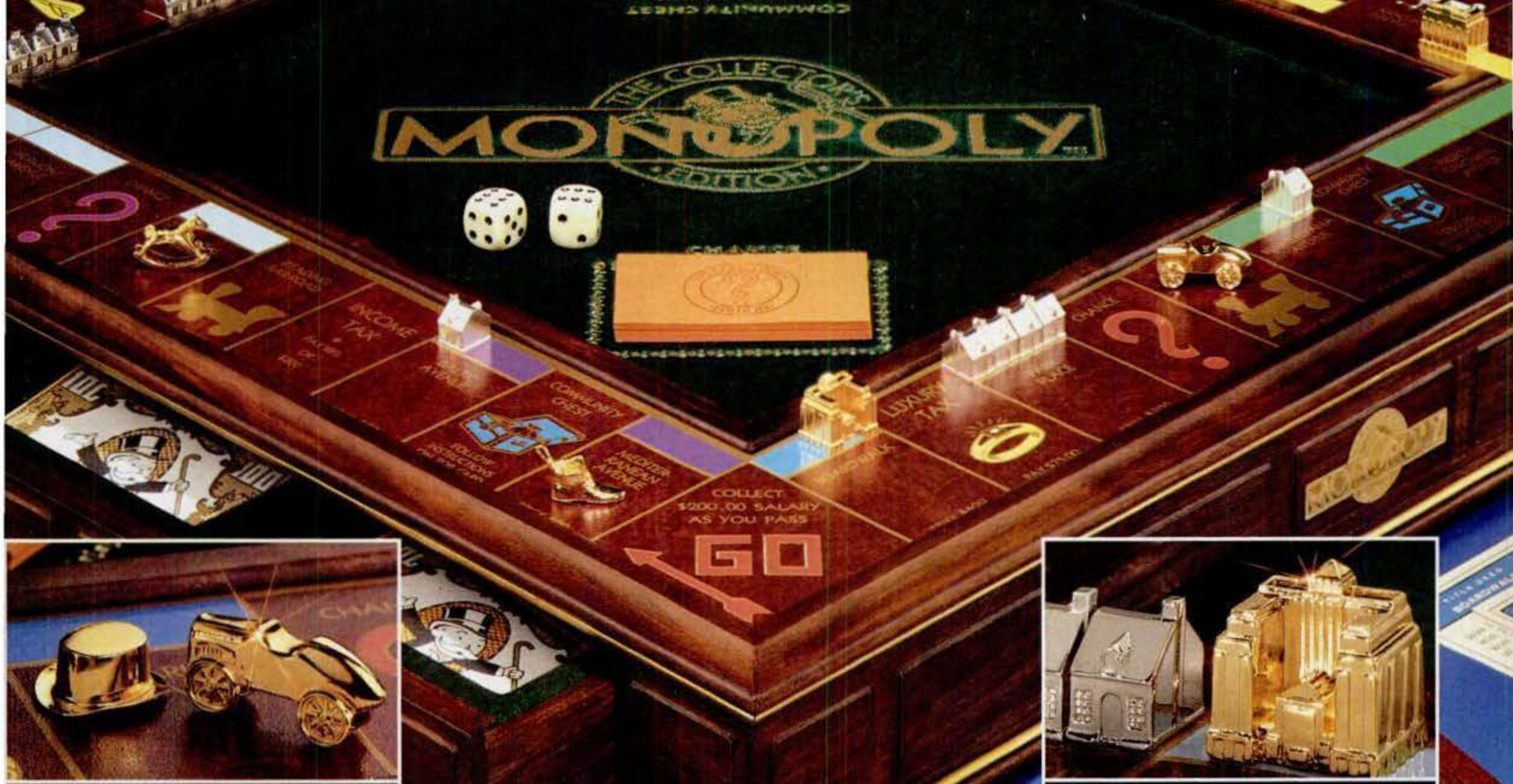

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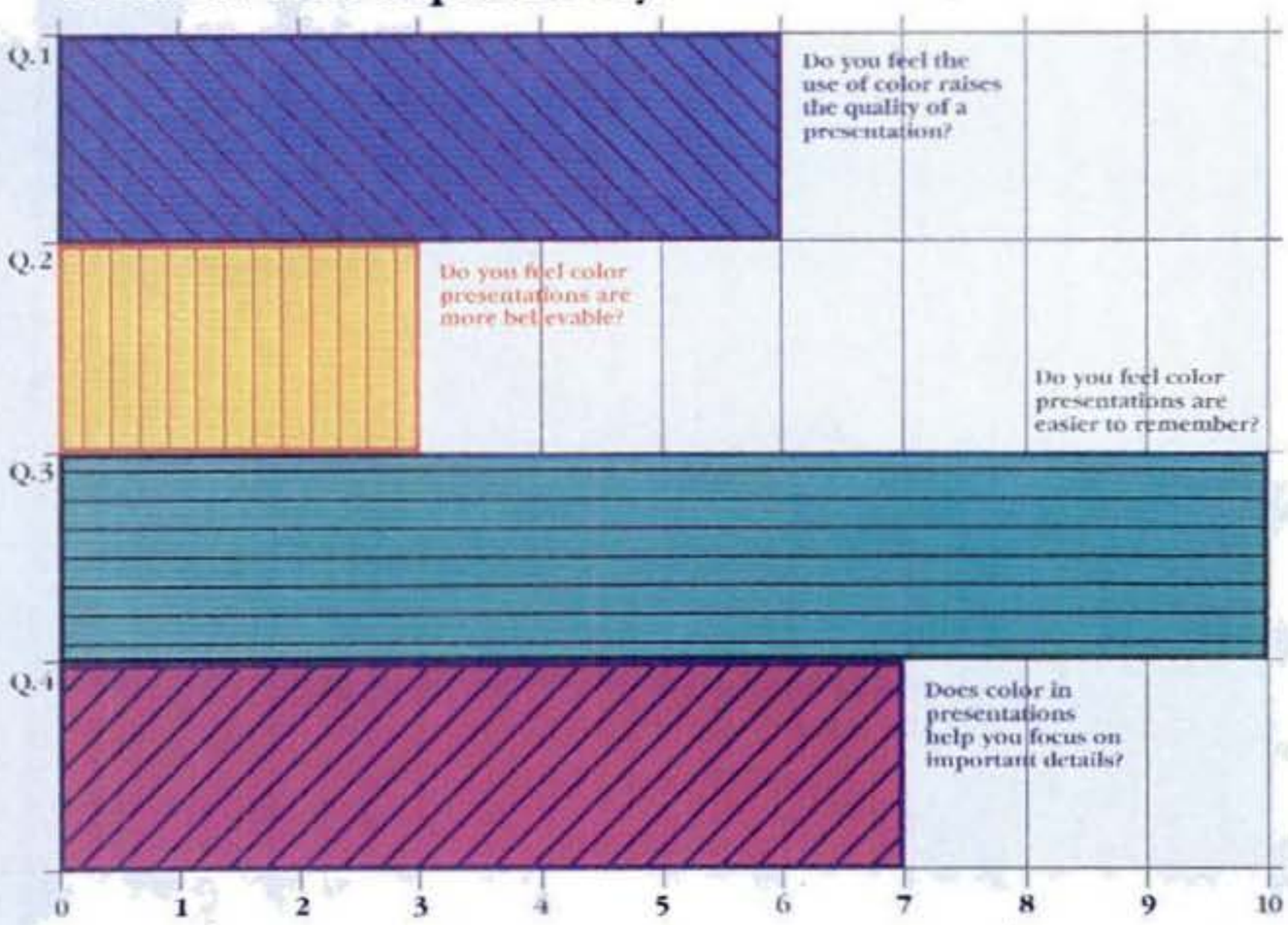

Together at last.

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WHAT'S NEW

COMPOSTING ORB

With this composter, there's no need to mix materials with a pitchfork; just roll the three-foot-diameter container for even decomposition of its contents. Made of corrugated plastic, the $50 Tumblefeed doesn't require water or starter chemicals. Shape Plastics, Box 538, 206 New Factory Rd., Sharon WI 53585.

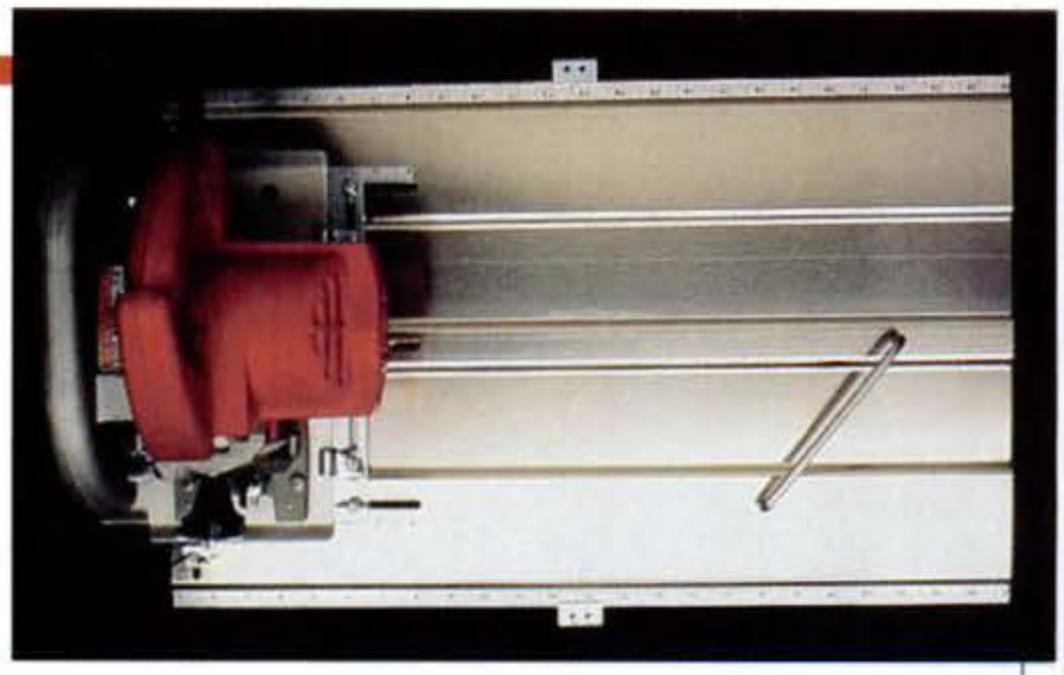
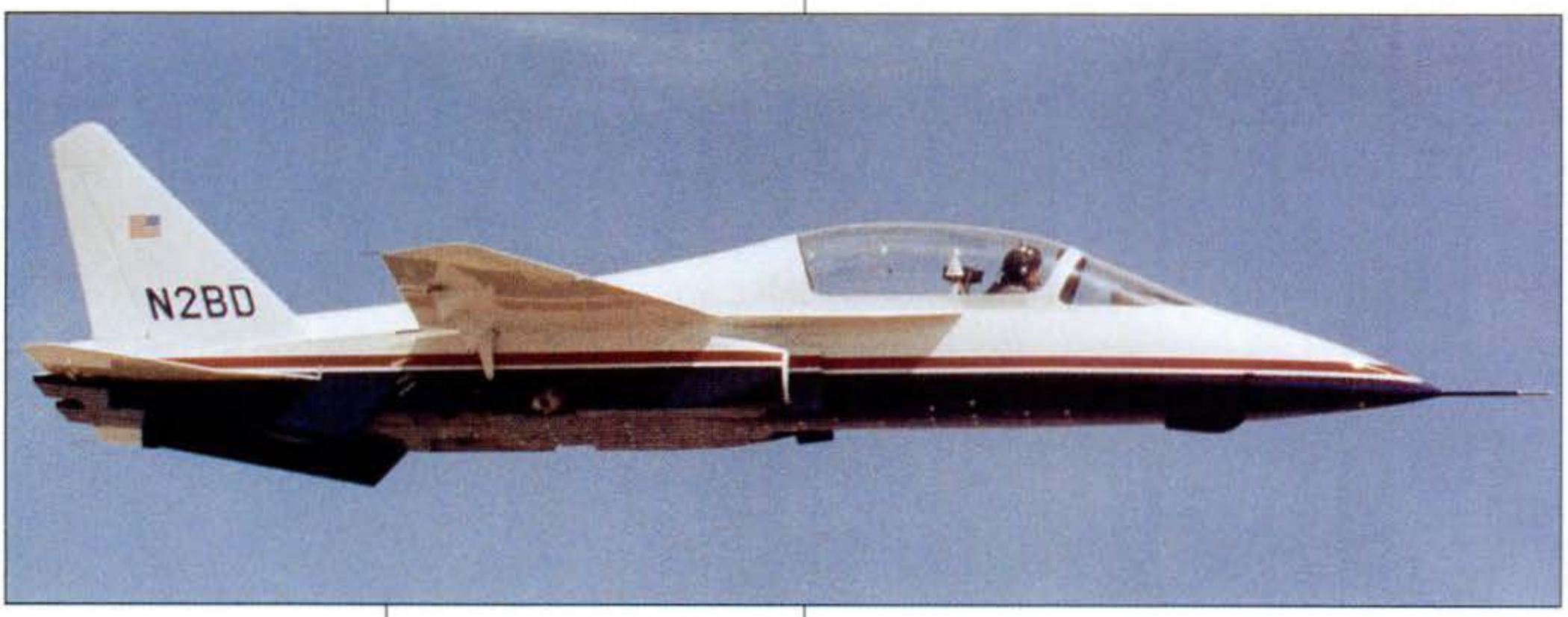


TABLE IT

Clamp the Porta-Rip to a circular saw, and it handles the same type of work as a table saw—except that the "table" is a mere 15-by-25-inch base. The $60 aluminum plate has 1/16-inch increments for precise cutting. Masterbuilt Manufacturing, 450 Brown Ave., Columbus GA 31906.

HOME-BUILT JET

The BD-10 kit plane could reach speeds of Mach 1.4 and climb to 45,000 feet, claims the manufacturer. For $525,000 the two-person, fully equipped experimental aircraft comes with assembly assistance, flight-testing service, and flying lessons. Bede Jet Corp., Spirit of St. Louis Airport, 18421 Edison Ave., Chesterfield MO 63005.



NO-SPILL NOZZLE

This container's flexible spout pops up with a pull, then flexes in almost any direction to help you avoid spills. A cap snaps tightly over the spout to seal the container. Developed in Israel, the patented dispenser is not yet available to consumers. Arizaz Industries Ltd., 350 Fifth Ave., Suite 1901, New York NY 10018.

HELMET PROTECTOR

ProCap, a protective covering for a football helmet, increases the helmet's impact resistance to reduce the chances of head injury. The $40 polyurethane accessory conforms to the shape of the helmet and attaches with velcro. ProCap, 1673 W. 8th St., Erie PA 16505.

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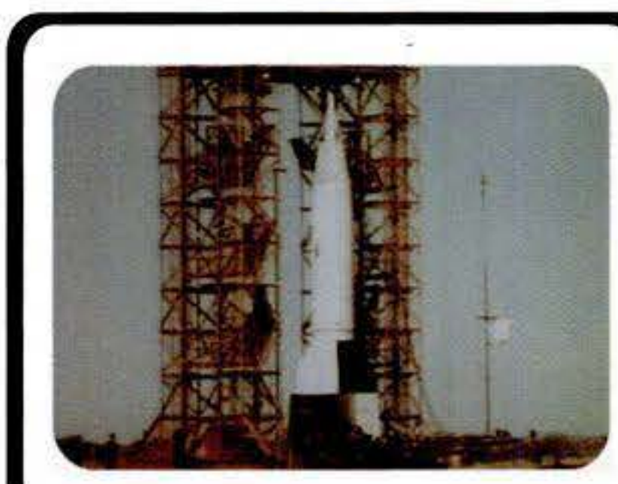

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WHAT'S NEW

A POUND OF COLOR

At 1.15 pounds, the Canon UC1 Color 8mm video camcorder is the lightest and smallest to date. The $1,799 subcompact incorporates a liquid-crystal-display color viewfinder with 100,000-pixel resolution, FM stereo, automatic focusing and white balance, and an 8X power zoom lens. Three main buttons and on-screen menus simplify operation.

BUDGET BENTLEY

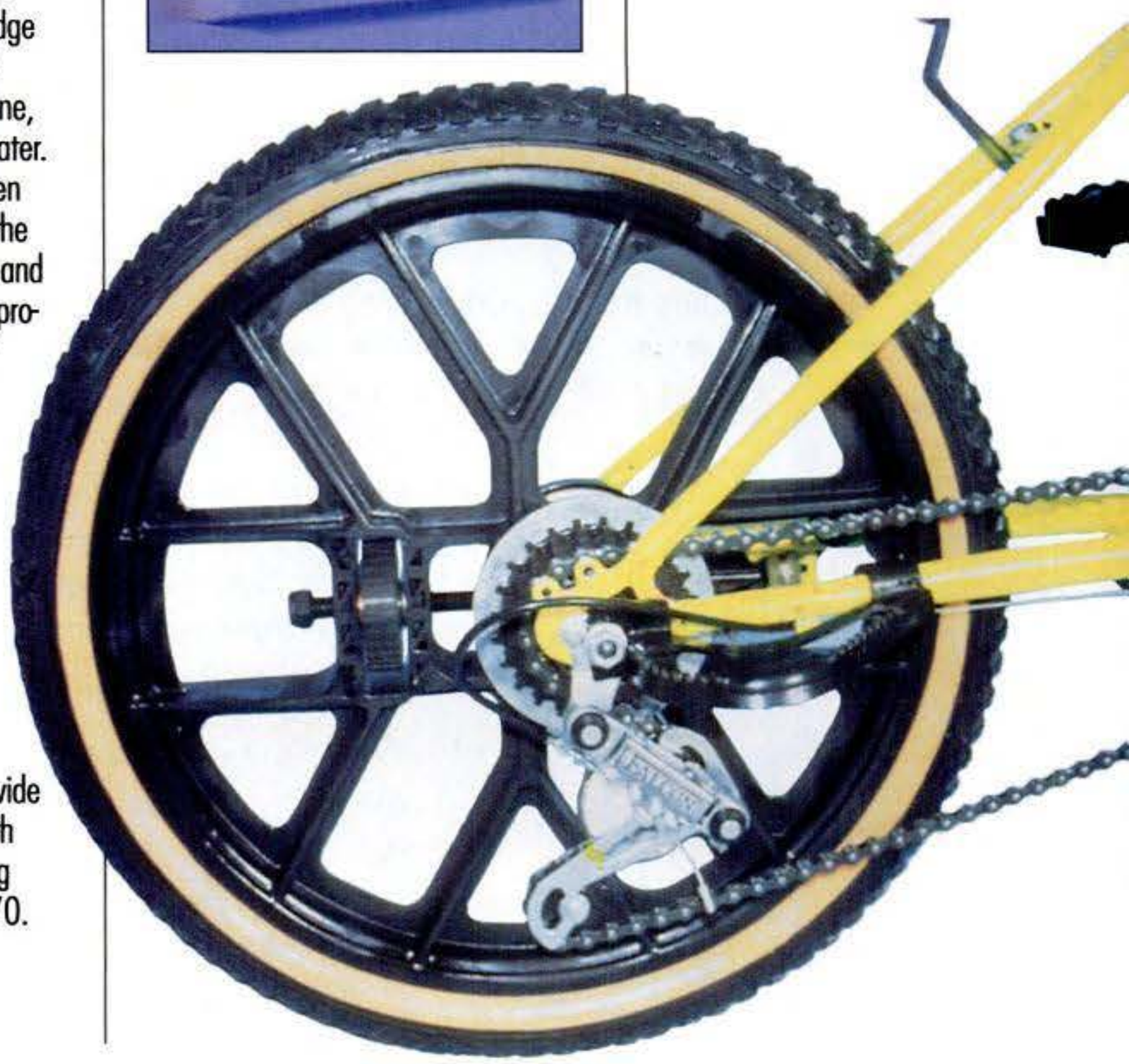
The four-door, five-seat Bentley Brooklands from Rolls-Royce has such practicalities as computerized suspension, four-speed automatic transmission, and a driver-side air bag. Standard luxuries include a hand-built 6.75-liter engine, remote-control security system, and ten-speaker stereo. Optional creature comforts: a liquor cabinet and voice-activated cellular phone. Price: $138,500.

ENERGY SAVER

The WT-1 Wall Timer helps save energy: The ordinary-looking light switch has a built-in programmable timer that turns a light off automatically after 15 minutes or at hourly intervals. Price: $25. Hemco, Box 878, Westminster CA 92684.

FILTERING PITCHER

The Mr. Coffee Water Filter two-quart pitcher has a built-in cartridge containing activated carbon and resin that helps filter lead, chlorine, and other chemicals from tap water. A gauge on the lid indicates when the filter needs replacing. After the two-hundreth refill, the lid locks and can only be opened with a key provided with the replacement cartridge. Price: about $35.



TWO BIKES IN ONE

The Rocking Rider not only pedals like a regular bicycle, it also adjusts to provide a more intense workout: The bike's center axle moves the front, back, or both wheels off-center by as many as four inches to create an up-and-down rocking motion for increased pedal resistance and an upper-body workout. Price: $170.

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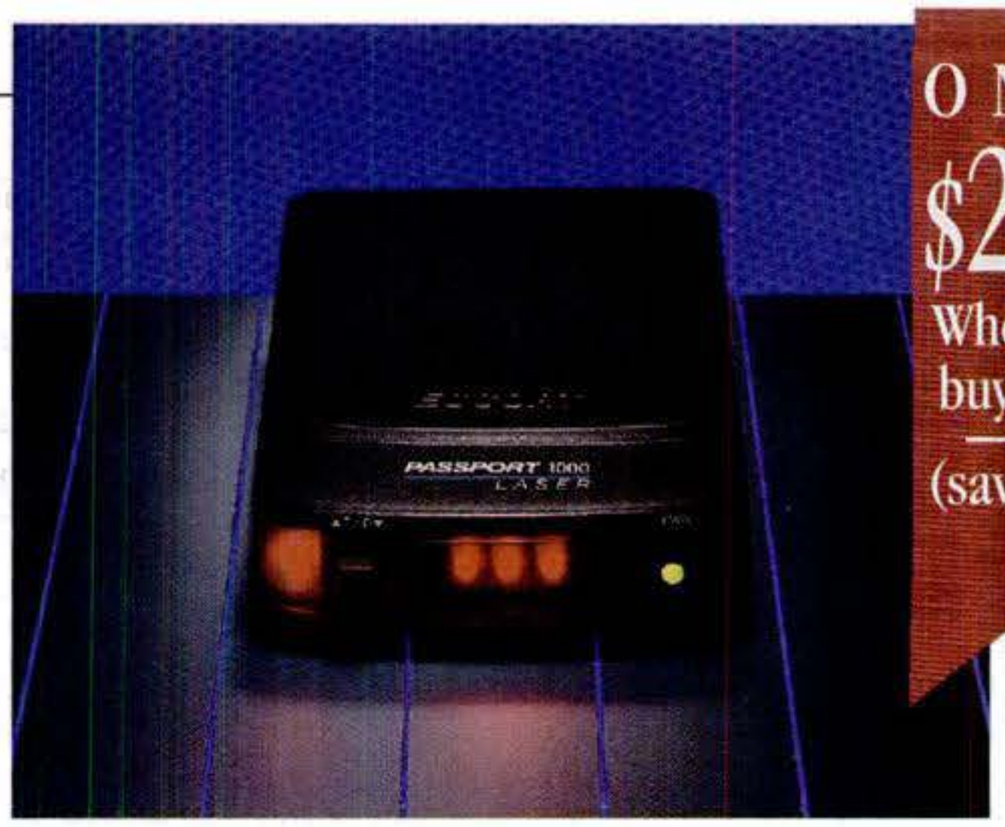

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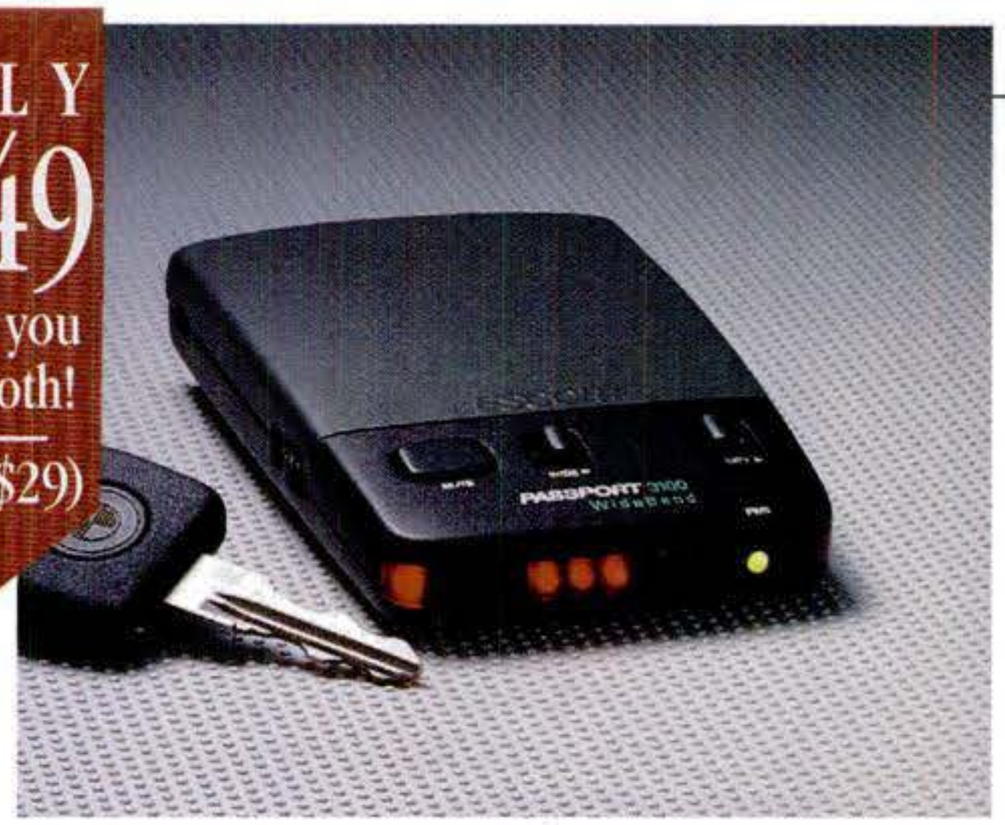

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Science Newsfront

Edited by DAWN STOVER

Telescope brain

Astronomers at a New Mexico observatory recently installed a high-speed computer, called a correlator, that will enable them to produce images of unprecedented resolution. In much the same way that your brain combines images received by your eyes, the correlator will weave together signals received by the Very Long Baseline Array (VLBA)—a group of scattered radio telescopes.

The VLBA, under construction since 1984 and soon to be completed, is a ten-antenna array that will be the largest and most powerful astronomical instrument in the world. With its ten-story, 82-foot-diameter antennas spread across the continental United States, Hawaii, and the U.S. Virgin Islands, the VLBA will have a resolution more than 100 times that of the Very Large Array (VLA), currently the world's largest radio observatory.

Because the antennas are so far apart, conventional data links are impractical. Instead, the data from observations at each site are recorded on 14-inch magnetic tapes that are up to five miles long. The tapes are synchronized by atomic clocks and shipped to the Array Operations Center in Socorro, N.M., the headquarters of both the VLBA and the VLA. There the tapes from all ten antennas are simultaneously replayed and correlated, enabling astronomers to create radio images of the objects under study.

The correlator is "a very specialized, dedicated computer that only does one thing, but does it very fast and efficiently," says radio astronomer John Romney, head of the VLBA Correlator Division. The correlator manages data from up to 20 tape drives, and it can handle antennas that may be added to the VLBA in other countries.

Meanwhile, European radio astronomers plan to construct a 20-telescope counterpart to the VLBA. The European Community recently agreed to help pay for a correlator that will be built at Dwingeloo Observatory in the Netherlands.—*Ray Nelson*

Testing the waters

Scientists studying meteorites from Mars have found that the extraterrestrial rocks contain small amounts of water—up to 0.4 percent by weight. A recent analysis showed that some of the water did not attach itself to the rocks after their arrival on Earth.

Everett Gibson at NASA's Johnson Space Center, Haraldur Karlsson at Texas Tech University, and Robert Clayton and Toshiko Mayeda at the University of Chicago looked at six rocks called Shergotty-Nakhla-Chassigny meteorites, or SNCs (named after the places where they were found), that are thought to have formed as a result of a large impact on the surface of Mars about 180 million years ago. Analyzing water extracted from the rocks, the scientists found it had high concentrations of two types of oxygen atoms that are rare in water found on Earth. More important, the martian water contained greater quantities of one type of oxygen than were found in the rock.

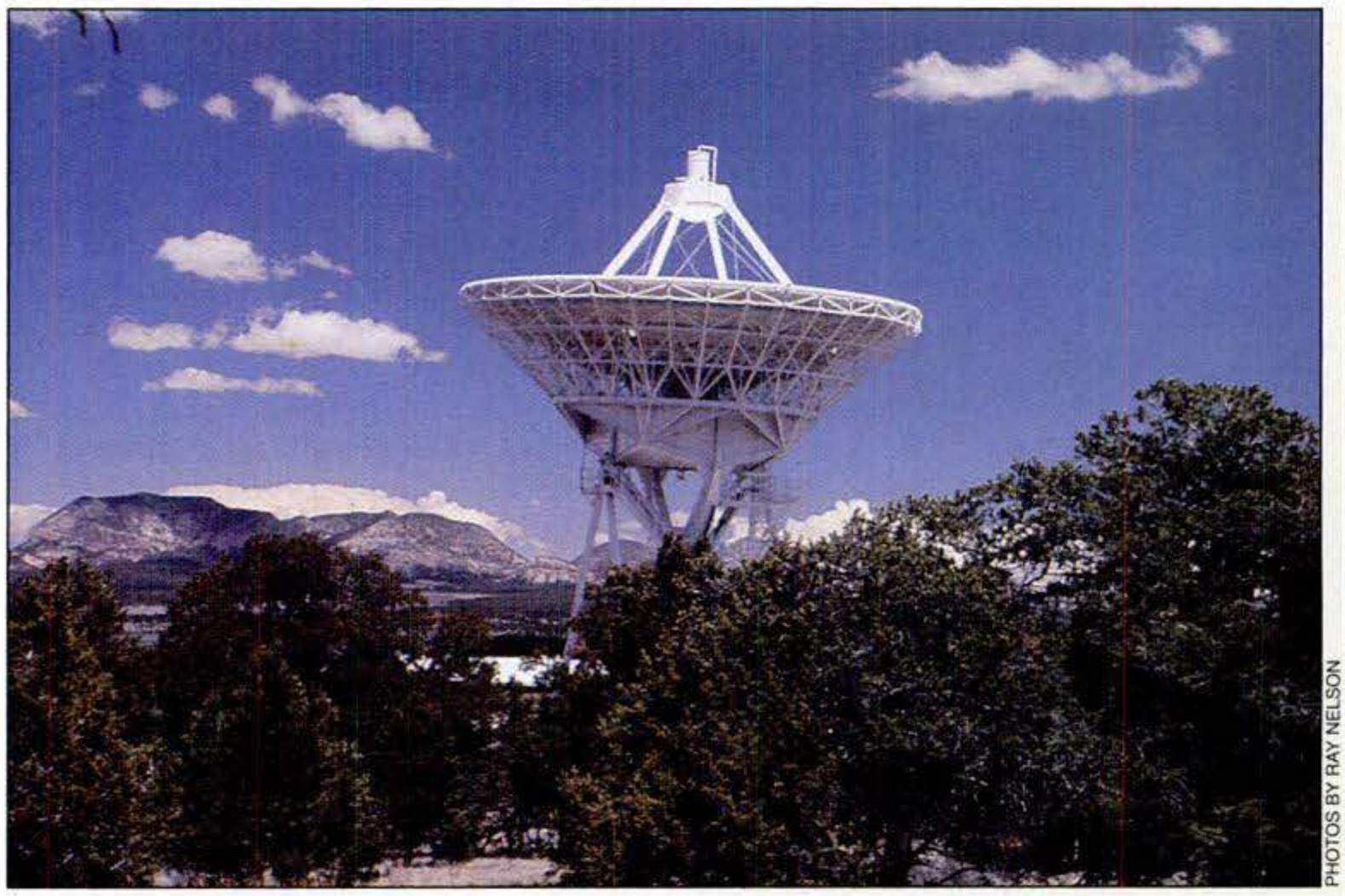
The study helps confirm that the martian surface has not undergone plate tectonics. "Here on Earth," says Gibson, "because of recycling of the crust by plate tectonics, the types of oxygen in the rocks homogenize over time."

The water found in the SNCs also indicates that Mars may once have had oceans or a water-rich atmosphere. Channels and other physical features on Mars are evidence of fluid flow, and many scientists believe that the fluid, probably water, is still frozen in the crust.—*Patricia Barnes-Svarney*

Sweet spotter

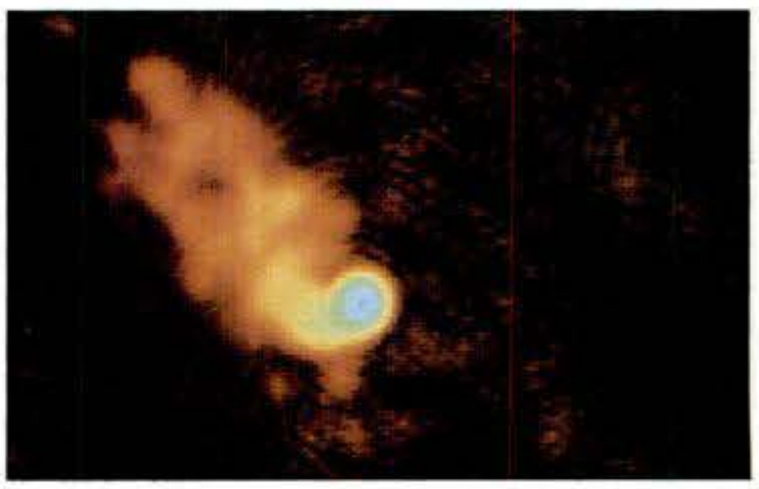
A Purdue University researcher has invented a way of using magnetic resonance imaging—a medical diagnostic technology—to determine the precise sugar content of fruits and vegetables. Gary Krutz, professor of agricultural engineering, says that his device could help food processors and supermarkets save millions of dollars. It could also allow diabetics to enjoy more fruit.

Krutz's machine, about the size of a microwave oven, subjects fruit to a brief, powerful magnetic burst. The hydrogen atoms in the fruit's water and sugar align themselves with the magnetic field for a fraction of a second, then flip back into their usual configurations. During their realignment, the atoms produce an electrical signal; the signal given off by sugar is different from that of water.



PHOTOS BY RAY NELSON

A radio telescope (above) near Pie Town, N.M., is part of the Very Long Baseline Array. An early image produced by the array, using 4 of its 10 telescopes, shows a cosmic jet in Markarian 501, a galaxy roughly 333 million light-years from Earth (right).



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Krutz designed the device for produce distributors, who would use it to decide which apples to put in long-term storage, which ones to ship immediately, and which to discard as overripe. He has tested it on apples and tomatoes.

"Right now we can measure sugar content within 2 percent, although our goal is 1 percent accuracy," he says. Sugar levels in vegetables range from 1 to 10 percent; fruit is 4 to 25 percent sugar.

Because sugar content is a measure of ripeness, supermarkets could use Krutz's machine to determine the optimal time to put fruits and vegetables on store shelves. "Supermarkets now discard 20 to 30 percent of all the fruit and vegetables they buy because they are overripe and rotting," says Krutz. "That represents tremendous waste, because these items have been picked, refrigerated, and trucked at great cost in labor and energy. If this tool can save just 5 percent of that 20 percent, it will pay for itself quickly."

Magnetic Instrumentation, an Indianapolis company, expects to begin selling the device to food distributors, baby-food makers, and supermarkets soon.

Diabetics are also interested in the machine. "They would like to eat more fruit to get their fiber and vitamins," says Krutz, "yet they want under-ripe fruit with low sugar levels, and they need to be sure."—*Jonathan D. Beard*

PATRICK LANDMANN FOR GAMMA LIAISON

This insect's elongated antennae help it survive in a Romanian cave with low oxygen levels.

Cave dwellers

Geologist Christian Lascu discovered a cave in 1986 while investigating a site near the Black Sea that the Romanian president Nicolae Ceaucescu had designated for a power plant. Inside the cave was an ecosystem that had thrived in isolation for about five million years—in conditions previously considered unable to sustain life.

The cave was off limits to both scientists and the public until August 1990, when, months after Ceaucescu's demise, a team of Romanian and American scientists was allowed to explore the cave. The scientists discovered more than two dozen previously unidentified species.

The newly identified species include insects, spiders, centipedes, and crustaceans. All possess physical characteristics such as elongated legs and antennae that enable them to survive in the cave's low-oxygen environment. The cave's atmosphere is only 7 to 10 percent oxygen; the normal oxygen level in air is 21 percent. A water scorpion found in the cave, the first ever discovered living below Earth's surface, is blind and has a pulmonary system enabling it to breathe through its tail.

Bacteria living in the cave acquire chemical energy from an abundant supply of hydrogen sulfide, normally a toxic gas. "The cave is the only known subterranean system relying on chemical energy coming from Earth rather than light energy from the sun," says Romanian cave biologist Serban Sarbu, currently at the University of Cincinnati and one of the first researchers to enter the cave. "It is the most interesting and at the same time the most atypical cave in the world." —*Bruce Gain*

Yeast feast

Ordinary baker's yeast cells can be used in place of mice or other laboratory animals to ascertain the toxicity of chemical substances, according to an Austrian professor.

Heinrich Koch and his research team at Vienna University's Institute of Pharmaceutical Chemistry have used yeast cells to test 150 chemical compounds—including medicines, industrial solvents, food additives, herbicides, and even substances like caffeine and alcohol. In every case, Koch claims, the results were equivalent to those obtained by animal testing. A detailed report on the tests recently appeared in the German science journal *Pharmacie*.

Conventional toxicology trials expose animals to varying concentrations of a test substance and try to determine the dose that kills 50 percent of them—a measure known as LD-50 (for lethal dose). The yeast test instead aims to establish the inhibitory concentration, or IC-50, at which 50 percent of the cells cease to divide.

To perform the test, the experimental substance is added to a battery of containers in increasing concentrations. Each container holds a few milligrams of fresh yeast and all the nu-

TOUGH SENSOR CAN TAKE THE HEAT

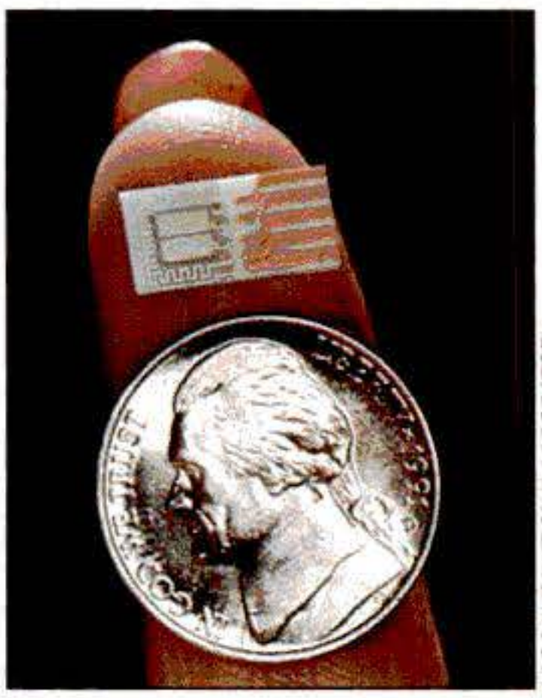
A new gas sensor made from a nickel's worth of materials can endure high temperatures, corrosion, vibrations, and exposure to water, according to its inventors at Argonne National Laboratory in Illinois. The tiny sensor detects a variety of gases.

Conventional silicon sensors do not work well at temperatures above 150°F. But Argonne's new sensor, made of ceramics and metals, is not affected by high temperatures. "The materials in this sensor behave well through a wide range of temperatures," says Michael Vogt, a control systems engineer at Argonne.

Vogt and his colleagues made the sensor by film-screening layers of ceramic and metal on a ceramic substrate, then firing the sensor in an industrial oven at more than 1,000°C. The Argonne researchers set out to build a sensor that would detect overheating computer components. Before an overheating component fails, and possibly ignites, epoxy in the circuit boards releases a gas. The Argonne sensor can detect this vapor and cut off power to the circuit.

The device senses gases by applying a steadily increasing voltage across its electrical leads and monitoring current spikes induced as gases react on the sensor's surface. Each gas reacts at a characteristic voltage, and the size of the current spike indicates the concentration of the gas. The sensor can detect the "signature" of several representative organic solvents.

The sensor could be used to monitor hydrocarbon emissions from cars; today's typical sensors only measure oxygen. The sensor could also monitor gases in industrial chemical processes.



ARGONNE NATIONAL LABORATORY

Made from a nickel's worth of materials, this gas sensor can survive harsh industrial environments.

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trients needed for the cells to multiply at a normal rate. Every 90 minutes, the cells are counted under a microscope. As the concentration of the test substance increases, the cells grow at slower rates and eventually stop dividing altogether. By measuring the dose-response relationship, the researchers can calculate the IC-50 of the substance. "In all the 150 substances on which we have experimental results, IC-50 is equivalent with LD-50," Koch claims.

Researchers at the University of Texas in Austin have also developed a substitute that could reduce the need for animal testing. They use a fungus called *Cunninghamella elegans*, which metabolizes a variety of drugs in much the same way mammals do. Dr. Patrick J. Davis, a professor of medicinal chemistry at the university's College of Pharmacy, says that although the fungus is useful in the early stages of an experimental drug's development, the drug must still be tested on animals before it can be administered to humans. —*Wordservice International*

A camera mounted on this remotely operated submersible, tested off the Florida coast, relayed images to video headsets worn by researchers on the surface—giving them a sense of "being there."

The next best thing

A remote-controlled rover may some day allow astronauts to explore vast areas of Mars without leaving their base camp. The Telepresence-Controlled Remotely Operated Vehicle (TROV), under development at NASA's Ames Research Center at Moffett Field, Calif., draws on virtual-reality technology to give astronauts the feeling they are cruising the red planet.

A camera and microphone mounted on the TROV will beam high-definition color images and stereo sound to a video headset that completely encompasses an astronaut's fields of vision and hearing. These stimuli will give the astronaut a strong sensation of "being there."

"[The rover] will allow scientists to more rapidly see the clues waiting to be picked up," says Geoffrey Briggs, scientific director of the Center for Mars Exploration at Ames. Remote controls will enable the astronaut to drive the TROV and collect samples with a manipulator arm.

The prototype for the rover, built by Deep Ocean Engineering of San Leandro, Calif., resembles a small submarine. When researchers wearing video headsets tested the system in the Florida Keys, they experienced a feeling of being underwater.

In October, researchers took the robot to Antarctica, an area that Briggs describes as "the closest thing we have to a martian analogue on the planet." There, a five-person research team used the remotely operated vehicle to study sediment on the bottom of an ice-covered lake on Ross Island. The researchers believe that primitive algae found in the sediment may be similar to organisms that lived on Mars billions of years ago.—*Devera Pine*

Wave power

A heaving float that converts ocean waves to electrical power holds the promise of becoming one of the most economical wave-energy devices in the world. It also holds up well during storms—a challenge for all devices designed to capture wave energy.

The University of California's Scripps Institution of Oceanography is testing the energy conversion device, which has an eight-foot-diameter float with a flat bottom and a domed top. "It looks like a flying saucer sitting on the ocean's surface," according to developer Tom Windle of Wave Energy in Bartlesville, Okla.

Beneath the waves is a spring-loaded pump, moored to the ocean floor. As a wave lifts the float, it stretches the spring. "During the troughs between the waves, the spring pulls back down," explains Windle. As it contracts, it pumps water into a turbine to generate electricity. Cables carry the electricity from the device to the Scripps pier, 1,200 feet away.

The system is similar to a Swedish hose pump, designed by Gotaverken Energy Systems, that uses an elastic hose instead of a spring to drive the turbine. Wave Energy's device won't be among the most efficient, but, like Gotaverken's hose pump, it probably will be among the most cost-effective. Both designs are simple and require little maintenance.

In rough seas, the Wave Energy device is submerged much of the time, protected from the destructive force of pounding waves. During last winter's storms, it survived eight-foot seas and a ten-foot tidal range. It operated until a faulty mooring cable broke.

The device is at the prototype stage, with an output of about 2.3 kilowatts —enough energy to light twenty-three 100-watt light bulbs. Eventually, Windle envisions using his device to provide power for desalination plants, methane production, or remote locations. He has patents in hand or pending in 21 nations. —*Gail Dutton*

A new whey to shave

When Lance Phillips whips up a foamy batch of cheese whey, there's no telling what he might do with it. So far, the Cornell University food scientist has made dessert toppings, biodegradable packing peanuts, even an edible shaving cream. And he thinks he can milk his patent-pending process for many other applications.

One of the substances Little Miss Muffet ate while sitting on her tuffet, whey is the watery, slightly sticky liquid left over from cheese production —90 pounds of it for every ten pounds of cheese. Cheese makers generate about six billion pounds each year in the United States alone. More than half of it gets dumped down the drain. "We're trying to take something that's not very useful and turn it into products people want," says Phillips.

He and fellow food scientist Scott E.

PETER MORENUS / CORNELL UNIVERSITY

A foaming process invented by Scott E. Hawks (left) and Lance Phillips turns cheese whey into edible shaving cream.

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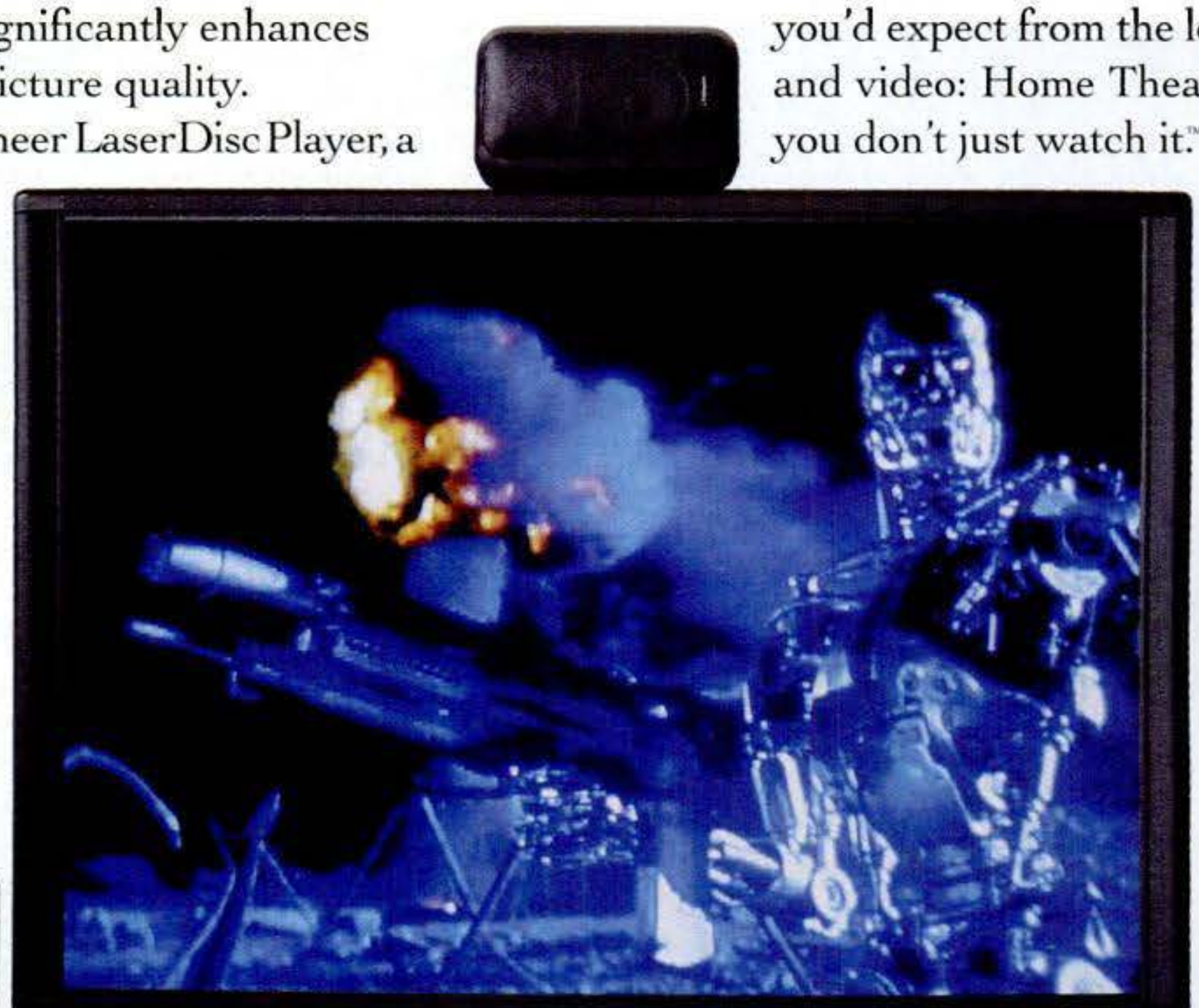

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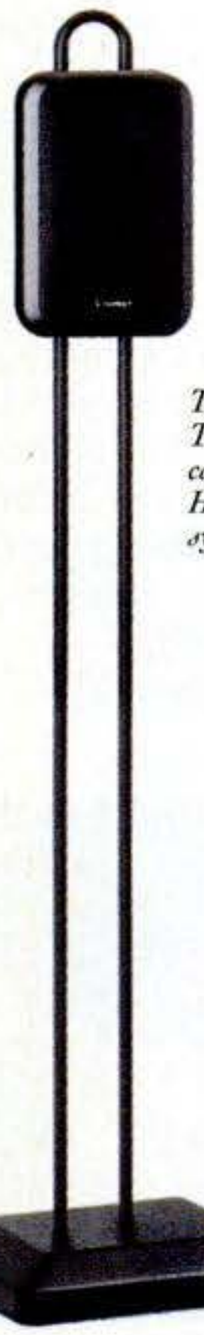

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Science Newsfront

HAIRY CARBON EXTENDS BATTERY LIFE

A new material that contains microscopic branching filaments of carbon could make batteries last longer. Engineers at the State University of New York (SUNY) at Buffalo who developed the material call it "hairy carbon."

Normal carbon fibers are about ten microns, or millionths of a meter, in diameter. But the fibers in hairy carbon are only a tenth of a micron in diameter—about 1,000 times thinner than a human hair. To the naked eye, the new material looks identical to normal carbon. But under the microscope, they look very different: The hairy carbon fibers are branching.

SUNY BUFFALO

Branching fibers in this microscopic sample of "hairy carbon" make it a superior conductor of electricity.

A team led by Deborah D. L. Chung, a SUNY Buffalo professor, uses a catalyst to grow hairy carbon from a carbon-containing gas. "Because of the hairiness, there is increased connectivity between the individual fibers," says Chung. That improves the electrical conductivity of the material.

In a battery, an electrode with superior electrical conductivity and surface area will last longer. Chung's laboratory tests show that electrodes made from hairy carbon last up to 50 percent longer than electrodes made from conventional carbon materials. Funded by the New York State Energy Research and Development Authority and the Department of Defense, Chung and her colleagues are developing a longer-lasting lithium battery that could be used for biomedical implants and aerospace applications.

Hairy carbon might also be embedded in plastic to make conductive polymers for electromagnetic shielding. Chung says manufacturers could reduce the amount of carbon filler used, without lowering the conductivity of the shielding.

Hawks have developed a process for whipping whey into fluffy mounds. First they remove the salts, sugars, and natural anti-foaming compounds found in the liquid. Next they add alcohol to unfold the neatly coiled molecules of whey's principal protein, creating "frizzy" molecules of globular whey. Then they beat the mixture in an ordinary kitchen mixer, and voilà —it foams.

The process can be fine-tuned for different products. A dash of oil stiffens the foam enough so beard stubble won't burst the tiny, trapped air bubbles the minute you lather it on. "You can't make it too stable, though, or it just won't wash down the drain when you're finished," says Phillips.

Adding sodium sulfate makes a sturdy foam that, when baked, could replace polystyrene packaging. Wet it, and it gets mushy and decomposes.

Whey doesn't have to foam to be useful. Chemical engineers at Ohio State University, for example, make sodium-free road salt from it. In Idaho, researchers from the USDA's Agricultural Research Service (ARS) use raw whey to keep topsoil from running off irrigated fields. Another ARS team grows fungi on a bed of cheese whey. The fungi produce eicopentaenoic acid, a rare compound that appears to reduce the risk of heart disease. A food scientist at the University of California at Davis is using whey proteins to make edible food coatings. And in Japan, highly purified whey protein is even used to make artificial ham.—*P. J. Skerrett*

Science notes

• What's your normal body temperature? It's probably not 98.6°F. That was the average temperature found in a 19th century analysis of more than a million readings from armpit thermometers. But a recent, more accurate study of 700 oral temperature readings from 148 volunteers found that body temperature oscillates during the day, and varies from one individual to the next. The study reported an average temperature of 98.2°F.

• Farmers fatten beef cattle with corn, but the animals also need roughage—it stimulates their stomachs' ability to absorb food. Now a researcher at Ohio State University has learned that six plastic pot scrubbers inserted into a steer's first stomach can satisfy its need for fiber. Steven C. Loerch, an associate professor of animal science, says that the pot scrubbers, which cost about $3, work as well as 500 pounds of hay.

• On Oct. 12, 1992, five centuries after Columbus landed in North America, NASA began a new search for extraterrestrial intelligence. The ten-year, $100 million search will be the most comprehensive one ever conducted. PS

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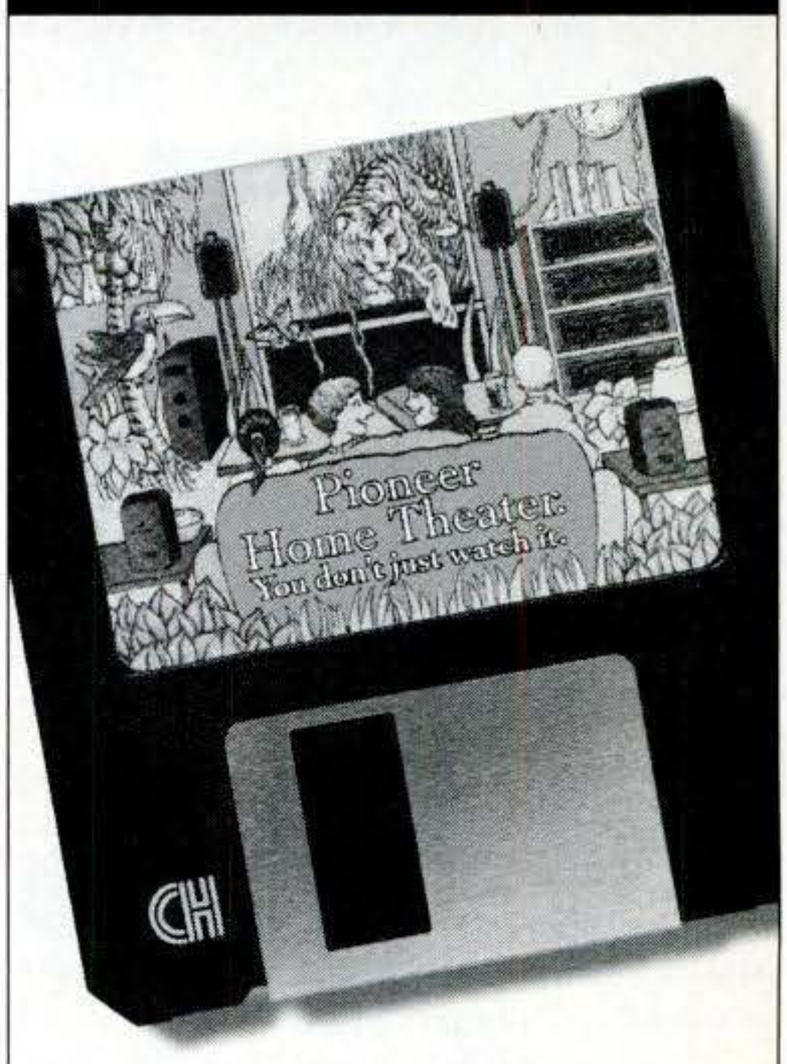

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Automotive Newsfront

Edited by DAN McCOSH

The new Lincoln Mark VIII is larger and lighter outside, with a wraparound interior theme (left).

Mark VIII: lightweight power

The 1993 Lincoln Mark VIII is a rolling showplace for Ford's new 4.6-liter DOHC, 32-valve V8, the latest in the so-called modular engine series that eventually will replace and modernize Ford's entire engine lineup.

The new multivalve engine develops 280 horsepower—nearly 25 percent more horsepower than the five-liter V8 in the old Mark VII. The all-aluminum block keeps the curb weight of the car down to 3,741 pounds—about 40 pounds less than the old car, despite being four inches longer and two inches wider.

Doubling the power in a lighter, stiffer chassis is the formula for a dramatic leap in performance, and the new Mark VIII delivers. It's quick off the line and then begins to put the hard squeeze on your stomach.

On a mountain curve, it handled potholes with ease—testimony to Ford's development of the air suspension system that was first introduced in the previous-generation Mark VII coupe. The front and rear air springs are self-leveling, and the system lowers the car's overall height about an inch at highway speeds.

The ride borders on plush, despite the fine-tuning for high-speed stability; this, coupled with the new stiff-and-solid chassis, results in a luxury-car ride that's rarely disturbed. The Mark VIII is not as aggressive as the Lexus SC400, however, and lacks the flat-out roadholding of an Acura Legend coupe.

The stylized interior is clean and modern, with two well-supported bucket seats and air bags for the driver and passenger. The exterior is a far smoother shape than the Mark VII, and its flexible bright grille is a plated plastic piece that withstands five-mph impact tests.

Engine preheater

A new heat-exchanger system speeds engine warmup by using heat from the engine exhaust to quickly heat the engine coolant.

Developed by Germany's Schatz Thermo Engineering, the cylindrical housing contains an array of parallel tubes that carry exhaust gas from the engine to the muffler. The housing is plumbed into the cooling-system water that surrounds the tubes, circulating around the baffles that lengthen the flow path to maximize heat transfer.

The water's close contact with the hot exhaust starts heating it the moment the engine fires. This warms the block and head much sooner than combustion heat alone, benefiting fuel economy and emissions.

Gas back-pressure in the heat exchanger causes the engine to produce hotter exhaust, and the increased temperature also shortens warmup time. After the initial cold start, the exhaust is diverted from the heat exchanger directly to the muffler.—*David Scott*

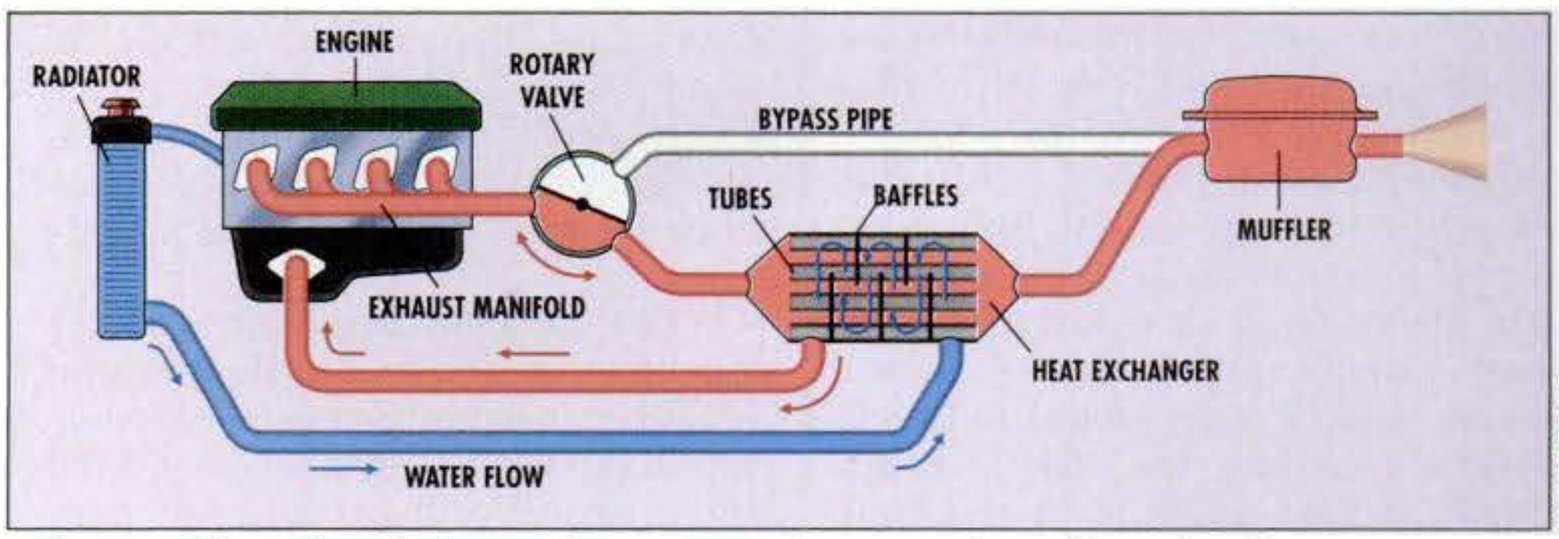
Electric profile

Mass-production of electric vehicles is just a few years away, promise some manufacturers, but the range limitations of electric vehicles still cause skeptics to write off electric cars as curiosities, or worse.

John Dabels, director of market development of General Motors Electric Vehicles, insists that GM will offer its new electric vehicle on a mass-production basis, appealing to everyday drivers rather than curiosity seekers or foes of internal combustion cars.

Dabels says research studies find that, contrary to popular belief, 84 percent of urban drivers travel less than 75 miles per day—well within the anticipated range of even a lead-acid battery-powered car.

Charging range of electric vehicles today is limited to between 120 and 250 miles, and the results of GM surveys in Boston, Houston, and Los Angeles dispel the fear that electric cars will suffer in the marketplace because they could need recharging before their owners get home.



Exhaust gas flows through a heat exchanger to speed warmup, then is diverted to the muffler.

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Still pleasing bikers after seven decades in production, BMW's flat-twin engine powers the new R100R Roadster.

Widespread acceptance is necessary, according to Dabels, because "we will need a retail market as well as a fleet market to establish values for used vehicles. A fleet market alone can't do this, and there's no way we can make a profit unless there's an annual market potential of 100,000 units a year at the very least."

Dabel says a late 1994 launch is planned for the GM project; the vehicles will be assembled in the former Buick Reatta plant in Lansing, Mich. The first models are slated to be compact two- or two-plus-two seaters and will be priced in the $20,000 to $25,000 range. They will be sold by existing GM dealers, probably chosen from luxury franchises.—*Maynard Gordon*

BMW's latest flat-twin

Engineers at BMW's motorcycle division have reached into their bag of parts and assembled the best all-around bike ever to be powered by its twin opposed-cylinder "boxer" engine.

Weighing only 445 pounds even with its big 5.7-gallon fuel tank full, the R100R Roadster has first-rate suspension, wide handlebars, and a low center of gravity that make it effortless to pilot through traffic or anywhere else.

The $8,000 Roadster uses BMW's Paralever double-jointed driveshaft design, which controls the tendency of the rear suspension on shaft-drive bikes to jack up and squat down as the rider changes throttle openings. Specially designed wheel rims have extra cast-in flanges that permit the use of modern tubeless tires with classic-looking wire spokes.

With 69 years of refinement in its design, the 1,000cc motor purrs distinctively and delivers plenty of useful torque. Its exhaust note is muted and dignified. Yet the venerable power plant may be one of the last examples of its kind: Believe it or not, the push rod engine's cheerful valve-clatter is getting it in trouble with tightening noise standards. And stricter exhaust emissions rules present another hurdle for these carbureted engines.

BMW knows a replacement is needed and has a second-generation boxer in the wings. Spy photos coming out of Germany show prototypes of an all-new flat-twin bike with multivalve cylinder heads, fuel injection, and an unconventional front suspension system. It's expected to surface sometime in 1993.—*Stuart F. Brown*

Long-wear tires

Sometimes even the most complicated computer simulations yield a very simple result.

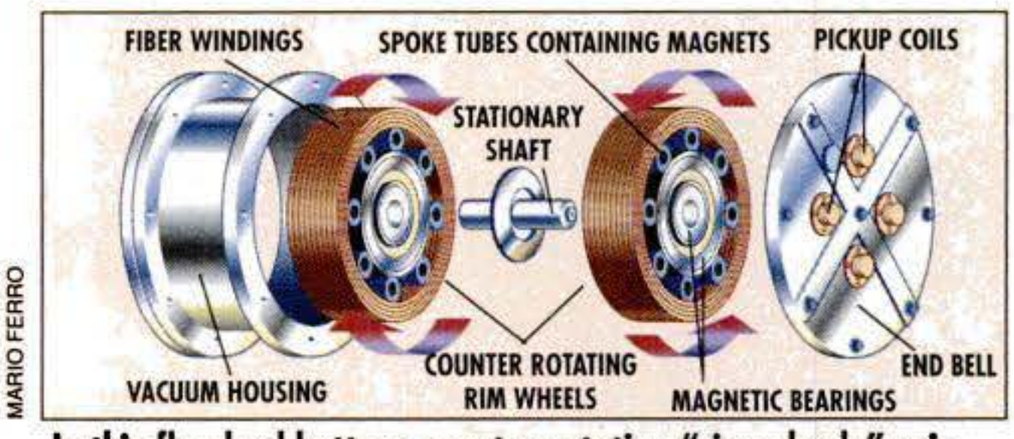
That was certainly the case for Michelin's new XH4, one of a new class of all-weather tires guaranteed to last 80,000 miles. After running more than 100 computer simulations of different tire shapes during an 18-month development period, Michelin found out that the key to a long-lasting tire was simple: make the tire wider and the tread flatter.

"In most tires, the shoulders are more heavily loaded than the center," says Mike Wischhusen, manager of product engineering at Michelin. "What we were able to do [by changing the shape] is equalize the pressure distribution across the tire." Michelin gives this basic change a rather fancy

FLYWHEEL POWER

A Seattle company claims its flywheel battery is the "missing link" that will enable electric cars to match the performance of vehicles powered by internal-combustion engines.

The American Flywheel Systems (AFS) battery contains a pair of counter-rotating "rim wheels," suspended by magnetic bearings in a vacuum housing. The rim of each wheel is made from a high-tensile-strength fiber, such as Kevlar. Spoke tubes containing magnets connect the rims to lightweight hubs. An electric charge sets the wheels in motion, and they can perform work as they continue spinning—like a potter's wheel.



MARIO FERRO

In this flywheel battery, counter-rotating "rim wheels" spin on magnetic bearings. Rotating magnets embedded in the spoke tubes induce an electric current in the pickup coils.

The idea of using a flywheel to store energy is not new, but designing a device that works efficiently and safely has proved difficult. To power a car, a flywheel battery must be capable of rotating at 150,000 to 200,000 rpm. If the flywheel is a metal disc, it could break into shrapnel at that speed. And if it is a spoked wheel, the rim pulls away from the hub at high rpms.

AFS claims to have solved some of these problems. For example, the new battery's spoke-tube assembly allows the flywheel rim to expand without separating from the hub. And when the rim is spun so fast that it fails, the Kevlar fibers simply turn into "cotton candy," says Edward W. Furia, chairman and chief executive officer of AFS.

Furia says his new battery could make GM's proposed Impact electric car go as far as 600 miles on an overnight charge. The Impact now runs on 32 lead-acid batteries and has a range of about 80 miles. Replacing the lead-acid batteries with 20 flywheel batteries, each weighing 30 pounds, would also improve the car's acceleration, according to Furia. He says flywheel batteries have a high power density—they can give up energy quickly.

"It's very important to overcome the perception of electric cars as glorified golf carts or greenmobiles," says Furia. "Electric cars should be capable of dazzling performance."

The flywheel battery would last about ten times longer than a lead-acid battery—which must be replaced after 25,000 miles. And since it uses no chemicals, it wouldn't create corrosion or disposal problems.

For now, the flywheel battery exists only as a computer simulation. It will take about two years to build a prototype for a car, Furia estimates. The battery could also be used to store electricity generated by solar or wind power.—*Dawn Stover*

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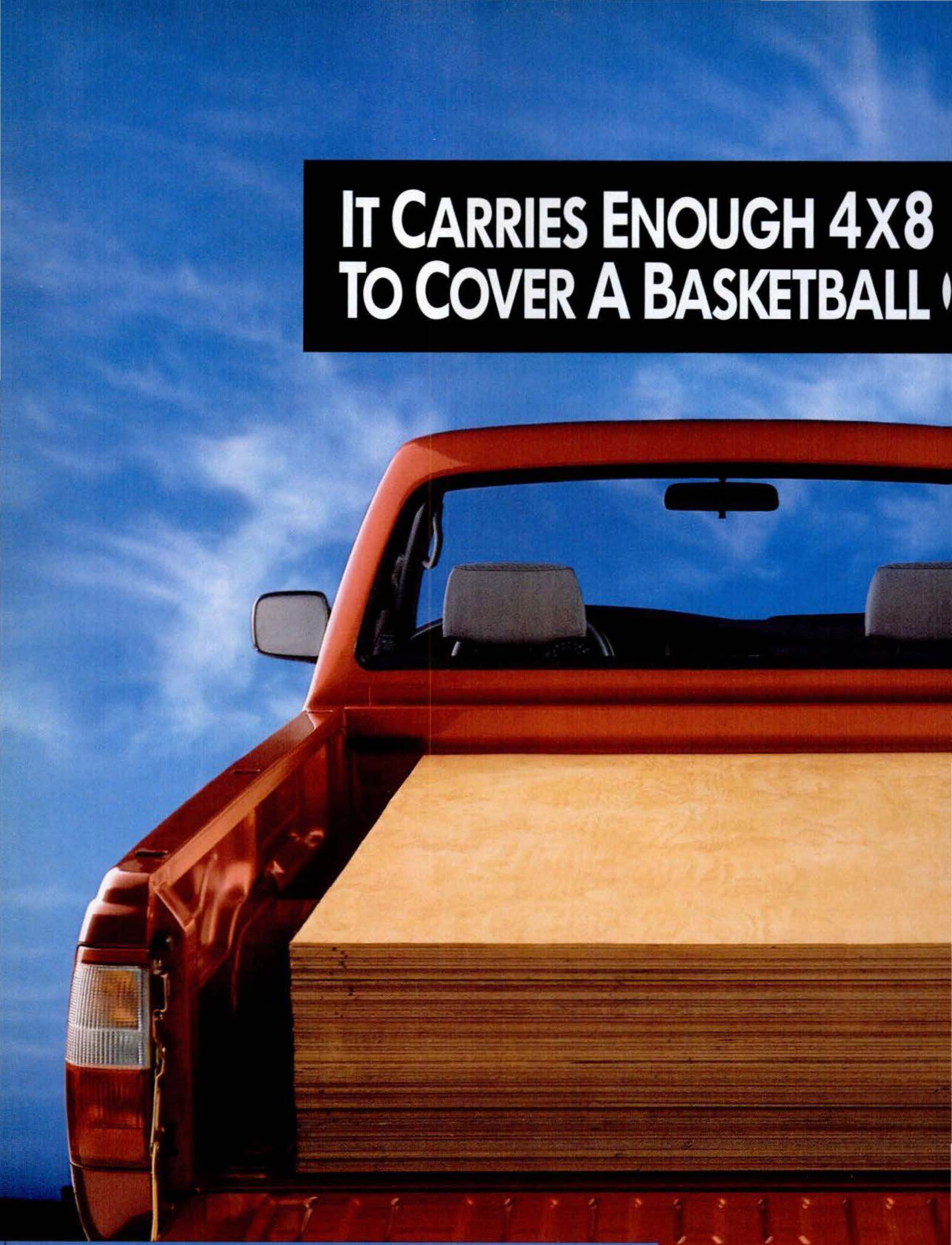
IT CARRIES ENOUGH 4X8 TO COVER A BASKETBALL



INTRODUCING THE TOYOTA T100.

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It's just the kind of bigger, roomier, heavy-hauling pickup you've always wanted in a tough Toyota Truck. But we didn't just build it big, we built it smart.

The rugged double-wall bed is constructed with anti-rust galvannealed steel sheets for longer life. So it's built tough to stand up to bricks, gravel, and yes, even a load of basketballs.

Toyota T100 features roomy 3-across seating and a bed big enough for 4x8 panels.

A winning lineup: Toyota T100 (available in 2WD and 4WD), Toyota Compact 4x4 and 4x2.

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As you can see, the all-new Toyota T100 is one big idea after another. But that's a story better told at your nearest Toyota dealer.

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The Toyota T100 One Ton.

"I love what you do for me."

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*Includes occupants, cargo, and equipment with 5-speed manual transmission.
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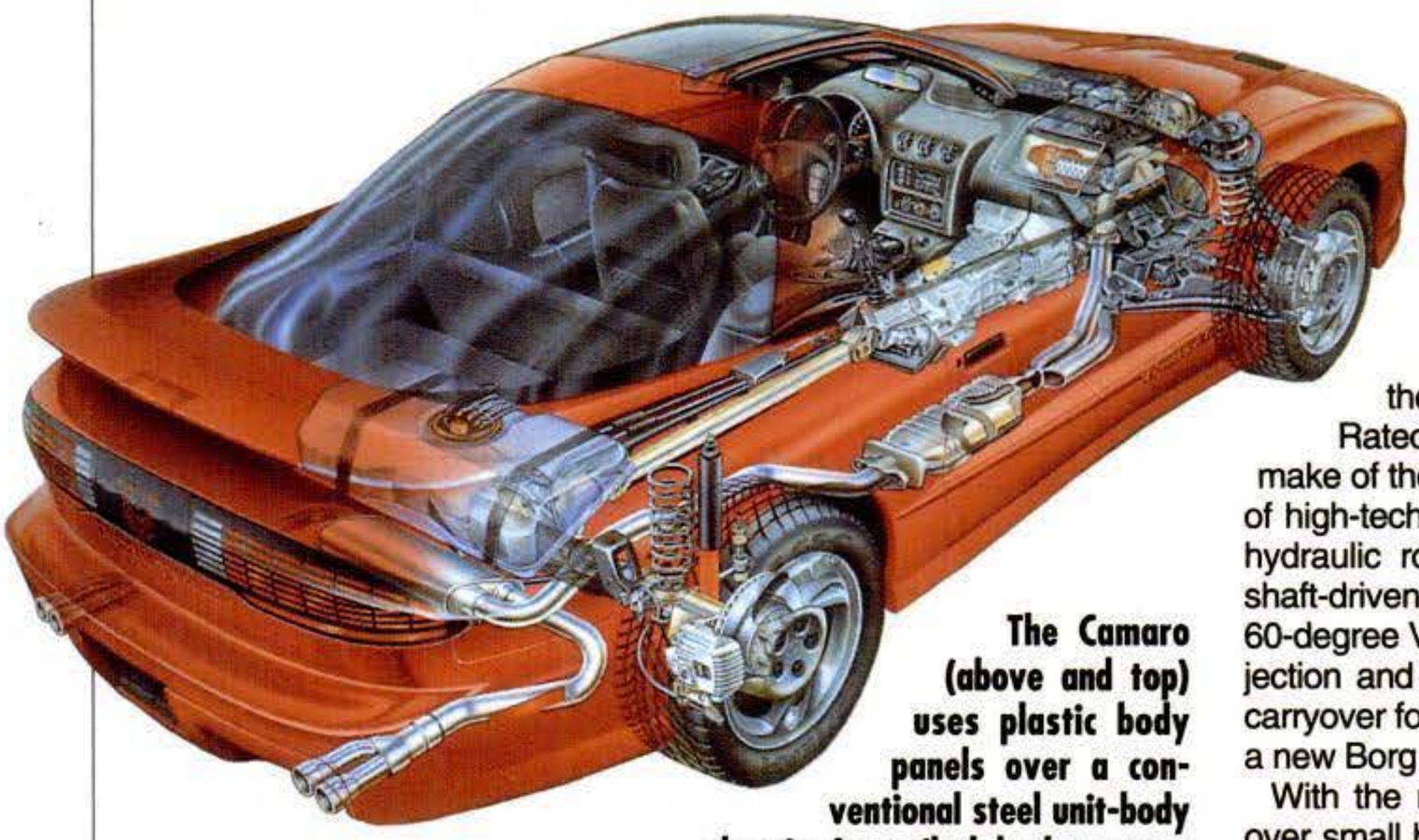
GM'S SPORTY PAIR GROWS UP



The Camaro (above and top) uses plastic body panels over a conventional steel unit-body chassis. An antilock brake system and dual air bags are standard; the top power-train options are the 275-hp LT1 V8 engine and a six-speed manual gearbox.

Chevrolet's Camaro and Pontiac's Firebird are now in their 26th year of production and fourth generation of design. Yet there's no indication of a middle-age slowdown in their maturity, thanks to a healthy infusion of horsepower from the 5.7-liter Corvette LT1 V8. The '93 F-body cars also attain a level of refinement previously unknown in these rear-drive muscle machines.

Camaro and Firebird have shared a common platform ever since General Motors released its reply to Ford's red-hot Mustang in 1967, and that's still the case. The 101-inch wheelbase and rear suspension are carried over from the '92 model, but not much more. Certainly not the sheet metal: The exterior skin is almost entirely plastic composite construction, with only the hood and rear quarter panels rendered in steel. The plastic components are neither lighter nor cheaper than steel, but the composites do allow the Camaro and Firebird to take on considerably different contours.

Civilizing the rough-edged F-cars was a major goal of the platform team, and in that respect they've succeeded. Squeaks and rattles, bane of the earlier vintages, are tamed by a far more rigid unit-body structure. A new Short and Long Arm suspension (SLA) replaces the former MacPherson strut up front, operating with greater compliance thanks to an impressive reduction in friction. Monotube gas shocks by French manufacturer DeCarbon are fitted at all four corners, providing a higher degree of damping precision and greater resistance to fade on long stretches of rough road. Rack-and-pinion steering appears for the first time on these cars too. Upgraded safety equipment includes GM's ABS VI antilock braking and dual air bags, both as standard equipment.

In a class defined by the throaty rumble of V8 engines, the F-car siblings stand out, benefiting from the LT1 engine. Rated at 275 horsepower in this application, this modern-day remake of the venerable Chevrolet small block gets the full complement of high-tech features, including the 'Vette's optically triggered ignition, hydraulic roller tappet camshaft, reverse-flow cooling system, and shaft-driven water pump. The base models get a 3.4-liter version of the 60-degree V6, now boosted to 160 hp and fitted with sequential fuel injection and a distributorless ignition. Transmission choices include a carryover four-speed automatic and five-speed manual for the V6, plus a new Borg Warner six-speed manual for the V8-equipped models.

With the revamped structure and suspension response (especially over small bumps), the Camaro and Firebird graduate from the realm of teenager's cruisers to responsible road machines. Yet the lusty V8 underhood ensures that the driving thrill of the Camaro and Firebird remains intact. Only the unadventurous exterior styling falls short of the leading edge. Early projections of price—less than $14,000 for the base car and the low $17,000 range for the well-outfitted V8 coupes—should put Camaro and Firebird right in the thick of the showroom battles, with only Mustang able to offer a credible V8 challenge.
—Norman S. Mayersohn PS

Stylists took advantage of plastic's production flexibility to create a separate, individualized look for the new Firebird.

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name: Stress-Equilibrium Casing. In addition to shape, incremental advances in rubber compounds helped make the 80,000-mile tire possible.

The only real compromise is comfort. Because the XH4 is less rounded and flexible than typical family sedan tires, it has a slightly harsher ride, admits Wischhusen.

Bridgestone has also recently introduced an 80,000-mile tire, the Turanza-S. A Bridgestone spokesman, however, attributes its durability more to general improvements in all-season rubber technology, rather than a new shape. Both the Turanza-S and Michelin's XH4 sell for about $60 to $110. Their warranties require that the car must be checked for alignment problems every 5,000 and 7,500 miles, respectively.—*Bob Langreth*

GM implodes

The abrupt resignation of General Motors chairman Robert Stempel leaves the future of many anticipated GM product lines in doubt.

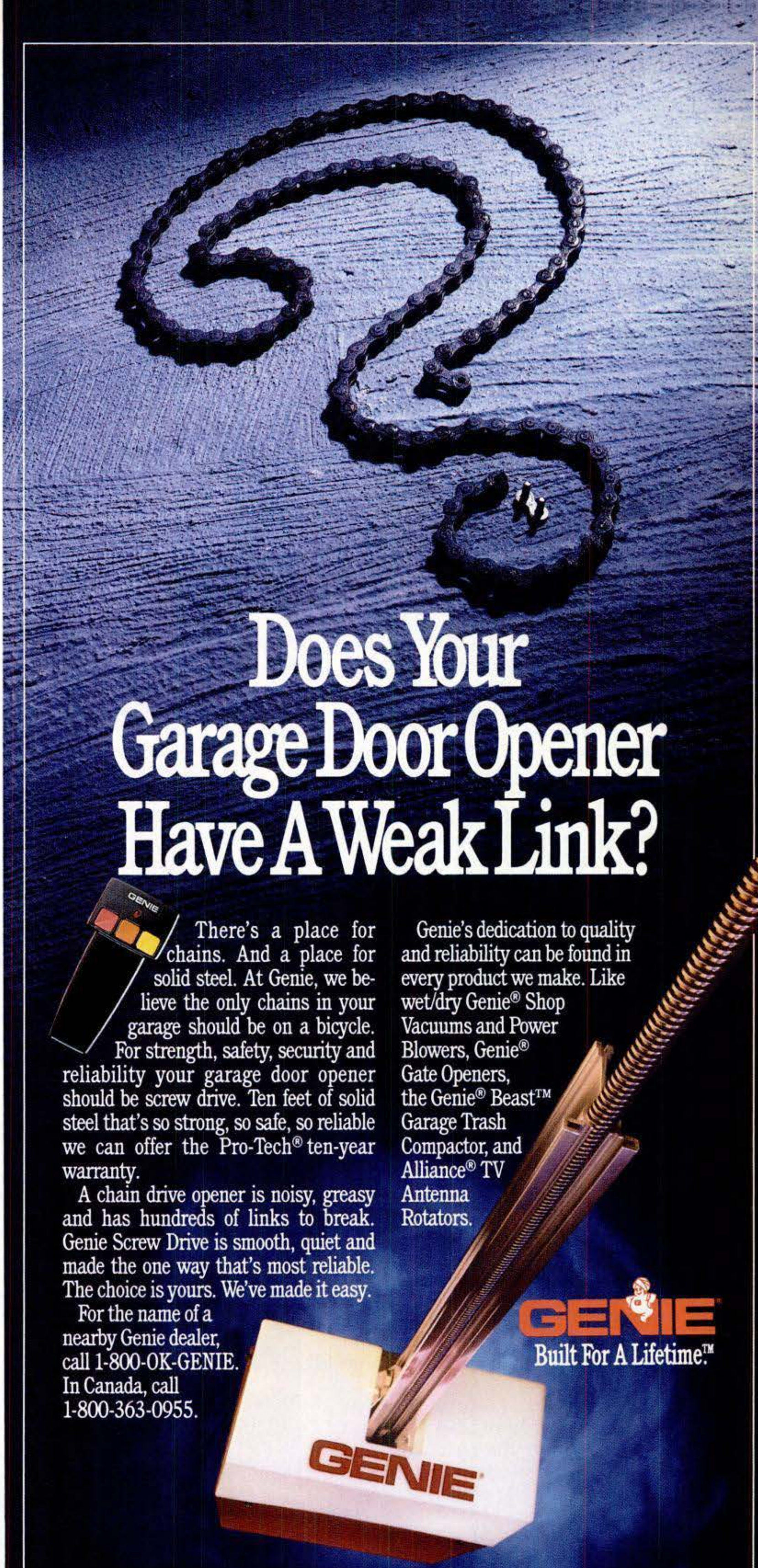
The radical changes at the world's largest auto company were driven by several years of record losses. But even before the shake-up, GM has been working on reducing the number of basic car platforms, consolidating its manufacturing operations, and cutting capacity.

Up to now, the main consideration was adding refined versions of costly basic platforms and components with little additional cost. A case in point: The Oldsmobile division is planning a new engine called the Aurora V8, a four-liter, 250-hp version of Cadillac's Northstar V8, to power the 1995 Toronado replacement. Made on the same assembly line, the smaller engine is tuned for less power and greater fuel economy than the Cadillac engine, with minimal additional cost in manufacturing.

In the face of the latest turmoil, however, far more severe cuts are anticipated—including eliminating nearly half of GM's existing car and truck platforms.

Getting the lead out

The elimination of lead from gasoline, begun more than 20 years ago, may be paying off in environmental benefits sooner than anticipated. The results of a recent study of lead concentrations in the forest floor of the Northeast surprised Dartmouth College researchers. "The United States' use of leaded gas has declined by more than 80 percent since 1970," says associate professor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The Ritter electric is one proposed answer to Europe's pollution problems.

Andrew Friedland of Dartmouth's Environmental Studies Program. "Thus we expected to find lead accumulating at a slower rate in the forest floor than in the past, but we did not anticipate the significant decreases we found for at least 50 to 100 years."

The Dartmouth group studied forest floor samples from 30 sites in Massachusetts, Connecticut, New York, New Hampshire, Vermont, and Pennsylvania in 1980 and again in 1990. Statistically significant lead reductions were found at six sites, some decrease or no change at 19 sites, and a slight but not statistically meaningful increase at 11 sites. On average, lead concentration decreased by 17 percent from 146 parts per million to 121 ppm between 1980 and 1990. The decrease, Friedland notes, suggests that atmospheric deposits of lead into the soil have been much less in the past decade than what the forest floor has exported.

So where's the missing lead going? Friedland says it does not appear to be entering streams and surmises that it is migrating with organic matter from the floor into the underlying mineral soil. Dartmouth is conducting further research to find out.

Candy-maker's electric

It looks and sounds like a diminutive space-age go-cart, weighing less than 1,344 pounds—and it doesn't run on gasoline.

El Sport is one of several prototype electric cars that have been developed in Germany over the past year. And it's certainly the country's first to be financed by a popular chocolate candy-bar producer.

Thirty-eight-year-old Alfred Ritter III is an ardent environmentalist. Approached a year and a half ago by a group of four young engineers seeking money to build an electric car, Ritter jumped at the opportunity.

A prototype was built by the design team in about 12 months. This year the group plans to build around 100 vehicles, each expected to cost between $25,000 and $30,000.

Lightweight composite materials of plastics and aluminum and low-drag aerodynamics give El Sport a top speed of 75 mph. The front-wheel-drive vehicle is equipped with an 8- or 16-hp asynchronous motor powered by a 15-kilowatt zinc-bromide battery. The zinc-bromide battery can be charged by plugging a cable into any normal European 220-volt electrical socket for around five hours. Battery power provides about 125 miles of city driving.

The specially designed bubblelike body compensates for the bulky battery and allows for more passenger room. Two passengers can sit comfortably in the front seats and there is room for two children in the rear seat, with sufficient space behind them for two pieces of luggage.

The Ritter effort joins Germany's other big carmarkers that are exploring the future of electric vehicles. Volkswagen and BMW have already launched their own prototypes, and Daimler-Benz is busily developing its own.

Interest in electric cars is heating up in Europe at a time when many European cities are considering bans on gas-burning cars. Italy already has plans to start closing its city centers to all but electric cars beginning in 1994. And although the issue is hotly debated in luxury-car-crazy Germany, the country is expected to follow the same route. PS

P R E V I E W D R I V E

COMING : SPEEDY ELECTRIC DELIVERY

A loose wire limited my test drive to two miles over city streets, and I never reached speeds above 30 mph. But that's exactly the kind of around-town service Ford's Ecostar van is likely to see when it enters U.S. test fleets this year. "We tried to make it as similar as possible to a gasoline vehicle," said Ecostar Program Manager Robert Kiessel. Indeed. The dashboard contained conventional heating and air-conditioning controls as well as the usual gauges—although one indicated range in miles to discharge.

On the floor, the automatic gearbox offered four choices: P, R, N, and D. Shift into D and you need to keep your foot on the brake or the little van creeps forward, just like a conventional vehicle. Acceleration off the line is slow at first, but speed quickly builds to provide more than adequate performance. The brakes performed flawlessly, and ride quality—even on severely potholed streets—was exceptional. The van rolls on Firestone Concept EVT tires inflated to 50 pounds per square inch. Once you're cruising at, say, 30 mph, shifting into neutral produces the uncanny sensation that the little van will simply roll on forever with no additional power needed. An alternating-current electric motor drives the front wheels through a single-speed transaxle, for a claimed top speed of 75 mph.

The van I drove had lead-acid batteries, limiting range to 30 miles. The test-fleet Ecostars will be equipped with sodium sulfur batteries that will give a 100-mile range.—*Richard Stepler*

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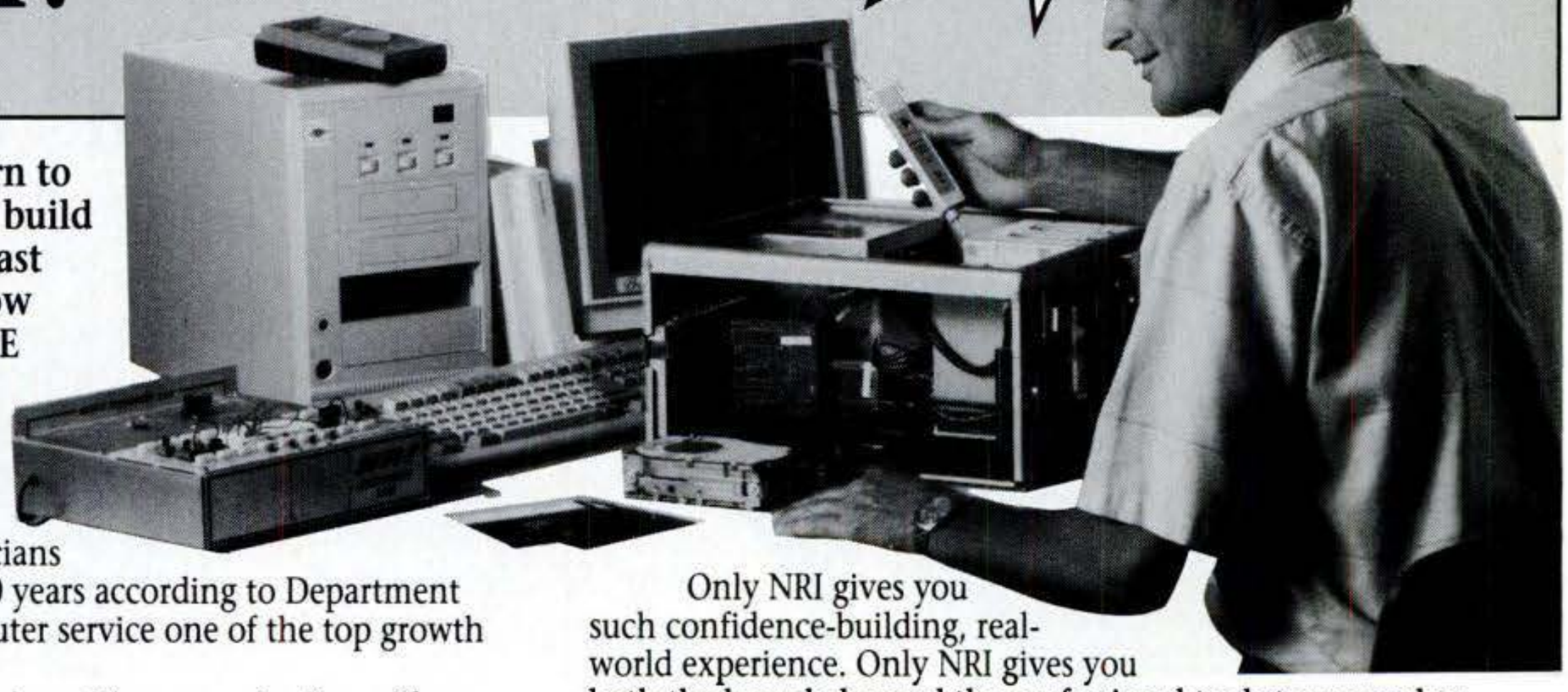

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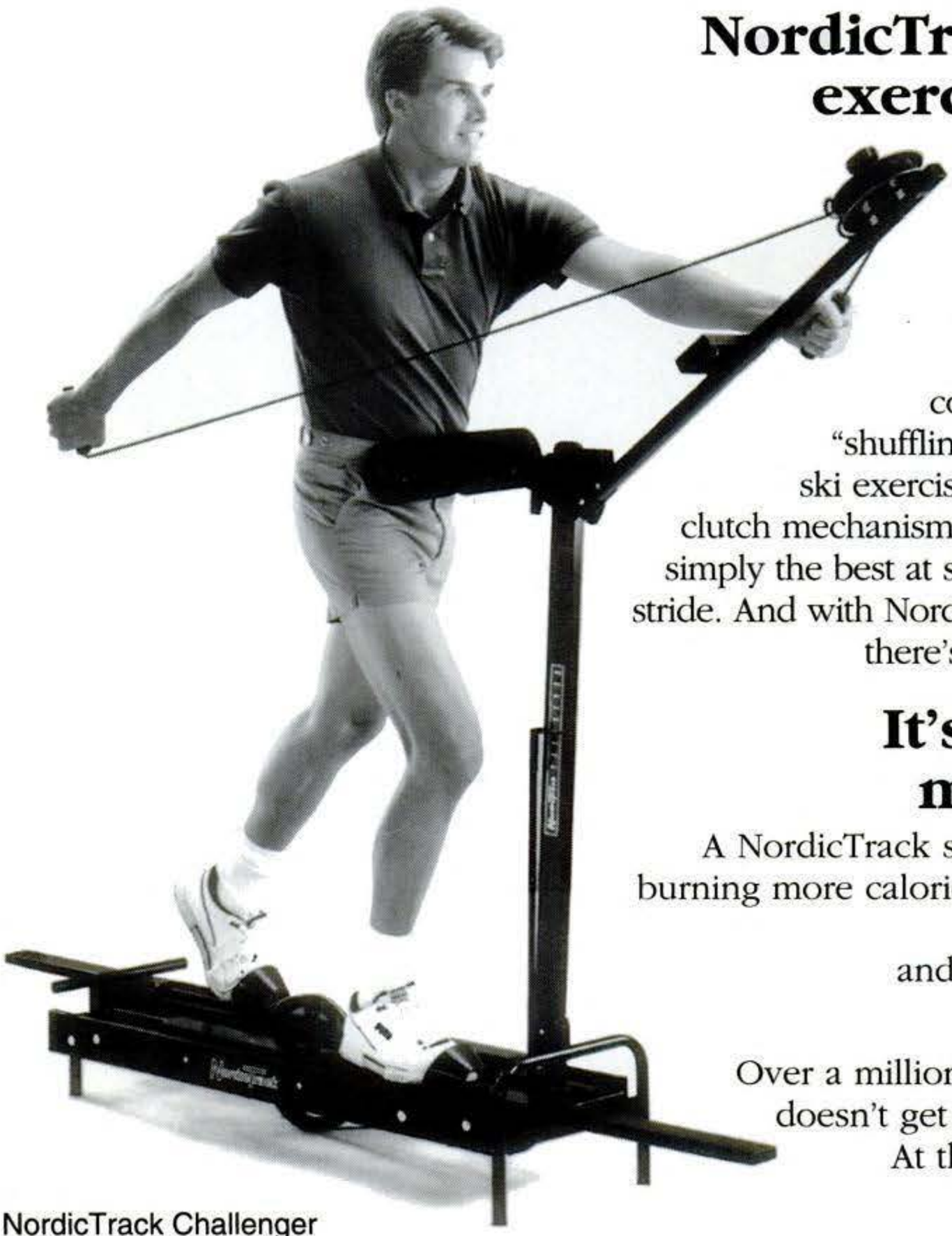

NordicTrack Challenger model shown.

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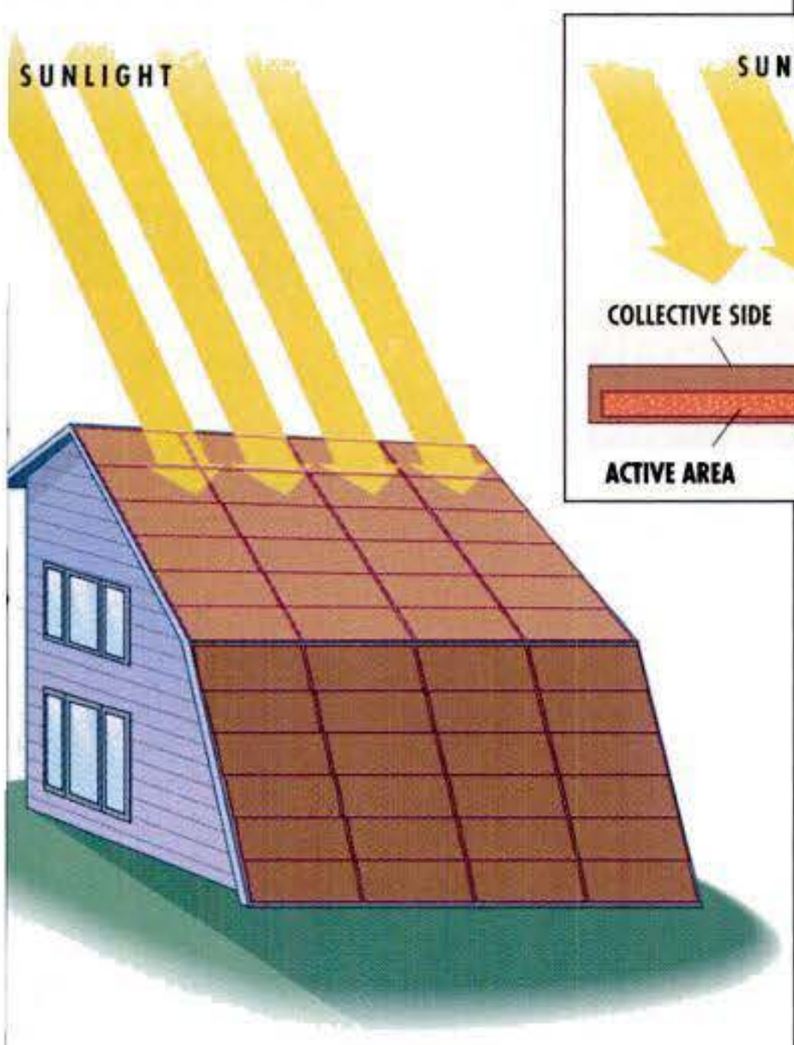
Home Newsfront

Edited by MARIETTE DiCHRISTINA



Interlocking solar panels act as shingles in a project by Japanese manufacturer Sanyo.

Sunroof for houses

The world of roofing has not had many new ideas since thatch: Tar paper and cedar shingles alike are laid down in the same overlapping layers preferred by prehistoric nomads. But a new, slim shingle from Sanyo takes a more modern approach. Built of glass tile and protective film, it doubles as a solar cell.

Sanyo has developed amorphous silicon that generates twice as much photovoltaic energy as crystalline silicon. That allows the shingles to emit a two-kilowatt current during the day. "This is enough electricity to supply all of the power for a typical house," says Martin Kawata, marketing technical engineer in charge of the project in the United States.

Sanyo's design is sufficiently straightforward to be installed by any construction contractor—rather than by a specialist in solar energy systems. The tiles overlap, like conventional shingles, but plug into each other snugly, eliminating the need for serpentine wiring schemes. Indeed, Kawata says the fit is so tight that traditional asphalt shingles to protect a home from the elements would be unnecessary. And the Sanyo panels would be lightweight, so that the usual special brackets and supports would be superfluous.

Unlike many solar cells, which are an odd hue of blue, Sanyo's shingles are a more conventional brown; the company hopes the color will appeal to homeowners concerned about appearances. The price and introduction date remain to be worked out; Sanyo is still refining the details of mass-production.—*Mark D. Uehling*

Roofs redux: now, plastic

From the company that designed the space shuttle's exterior tiles comes a unique roofing idea: polymers that essentially shrink-wrap an existing flat or low-sloped roof such as those on residential apartment buildings or commercial structures. The system is easy to apply, about the same cost as regular roofing, and may last longer, say officials at Lockheed Corp.

The roof is first sprayed with a 1/8-inch-thick layer of elastomers, materials that have properties similar to rubber. Next comes polyester fabric. As the fabric bonds to the first layer, another elastomer layer is applied. This waterproofing membrane is then sealed with a white reflective polymer coating. The materials maintain flexibility in temperatures from -20°F to 175°F.

Lockheed says that in the last two years it has replaced more than one million square feet of roofing on 20 of its buildings near Sunnyvale, Calif., with "excellent" results. "In our ten million square feet of roofing space, we've had every single type of roofing system—and every one of them has some problems," says Corey Leal, business manager of the program. "We developed this as a way to solve our own roofing problems."

Lockheed is initially marketing the process and materials to contractors.

Stopping faucet back flow

Those handy kitchen spray faucets could present a health risk: Experts say that the sprayers can absorb contaminated sink water. Drinking this water can cause problems ranging from stomach sickness to poisoning.

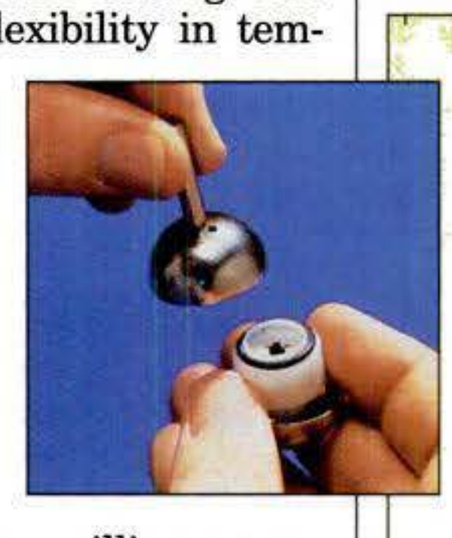
The problem, called back flow, can occur when the spray nozzle is left in the sink and water pressure drops at the same time. A pressure drop can happen, for example, when a nearby hydrant is turned on or a water main breaks. This decrease in pressure creates a vacuum effect, pulling dirty water into the faucet.

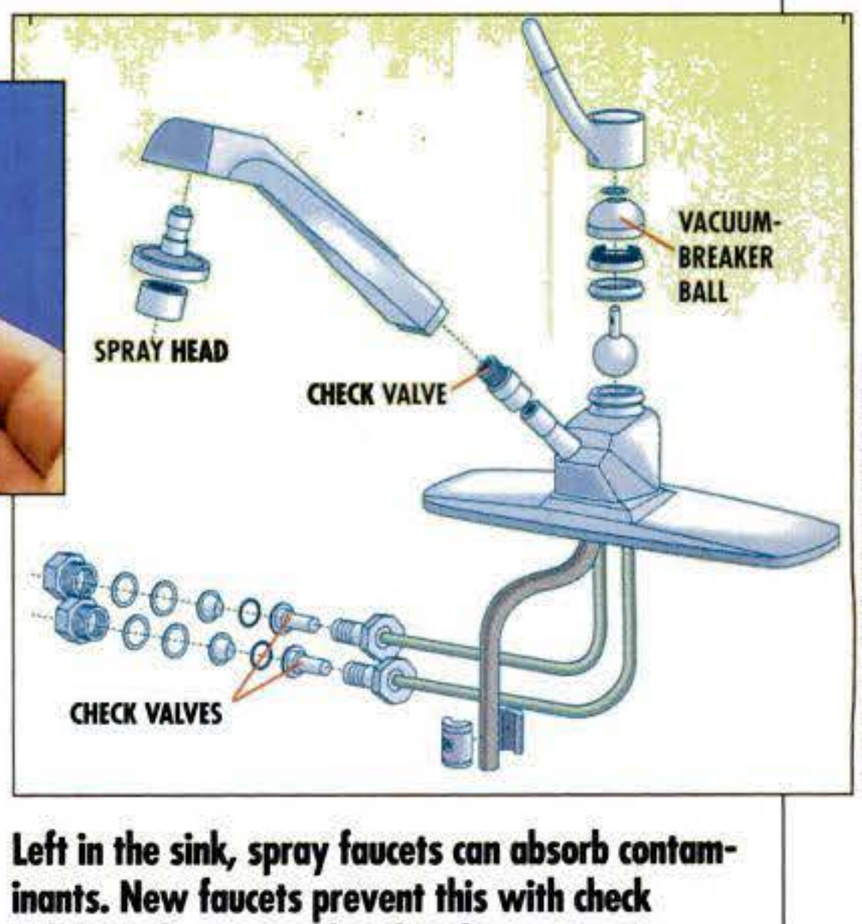
To tackle the problem, many kitchen sprayers have check valves that let water flow only in one direction—out of the faucet. However, according to the Building Officials and Code Administrators International Evaluation Services (BOCA), these valves can corrode or clog from debris. So valves aren't always enough to stop back flow.

Now, new spray faucets from Delta Faucet Co.—the Gourmet Spray ($200) and Deluxe Gourmet Spray ($295)—incorporate three back-flow stoppers: a check valve in the spray head, a second valve at the water inlet where the hose is connected, and a vacuum-breaker ball (see illustration below).

The vacuum-breaker assembly in the faucet body contains a small stainless-steel ball bearing that opens if water pressure changes. This allows air, rather than water, to be drawn through holes at the top of the ball.

These two faucets from Delta are





ILLUSTRATIONS BY STEVE STANKIEWICZ

Left in the sink, spray faucets can absorb contaminants. New faucets prevent this with check valves and a vacuum-breaker device (inset).

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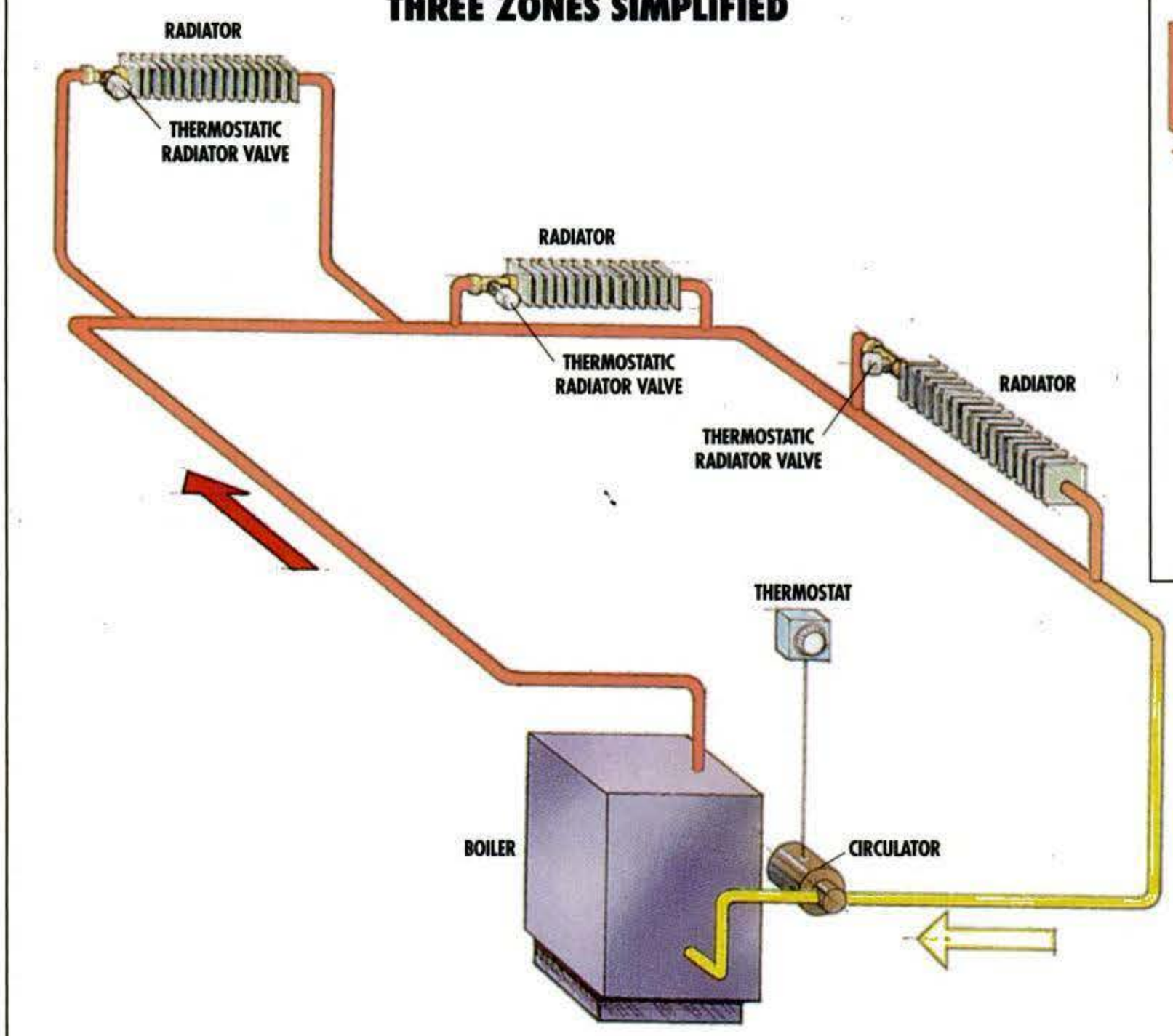
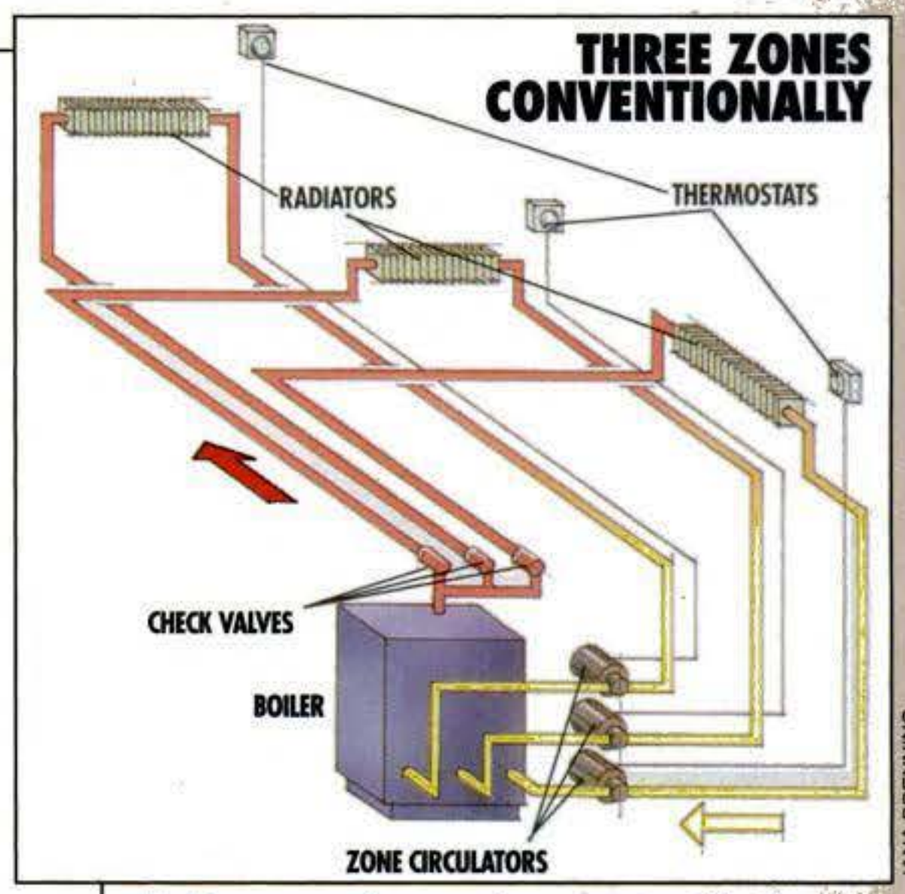
HYDRONIC HEAT FINDS ITS OWN ZONE

BY DAVID DOBBS





To give a room its own thermostat, a thermostatic radiator valve is installed in the room's radiator (left). This method of zoning is less expensive than the previous alternative, which was to provide each room with its own supply and return circuit from the boiler (above).

One of the most important principles in energy-efficient heating is zoning—that is, giving a house a number of independently controlled heating zones, each with its own thermostat. The more zones, the more energy-efficient the system. A zone for each room is ideal, because it allows the occupants to call, for example, 68- or 70-degree heat to only those rooms currently being used. Other rooms can be kept cooler.

Hydronic heating systems (also known as forced hot-water systems) commonly have only one or two heating zones. Usually the first floor has one zone, the second floor, another. Having more is expensive, because in conventional hydronic designs, each zone requires its own supply-and-return pipe and circulator.

A special valve called a thermostatic radiator valve (TRV), however, long used in Europe but only lately getting attention in the United States, lets you break an existing hydronic zone into multiple zones without running new supply-and-return pipes. By giving a fin-tube radiator or other hot-water radiator its own thermostatically controlled valve, a TRV can inexpensively add a one-room zone to either of the two main types of hydronic systems: the older-style series-loop system that dominated the market throughout the 1970s, or the newer monoflo, or "one-pipe," system that has been increasingly common since then.

In a monoflo system, the TRV is installed into the room's existing radiator loop (see illustration). In a series loop system, which lacks individual radiator loops, installing the TRV requires adding a bypass pipe that is just above or below the fin-tube radiator(s) in the room or rooms that you want to zone.

In either system, the TRV works the same way. As the room's temperature strays from the set point chosen on the dial, a temperature-sensitive wax or vapor within the TRV contracts or expands, slowly opening or closing the valve to adjust the hot-water flow through the radiator. This constant adjustment of water flow keeps the room temperature within 1.5 degrees of the set point.

The result is accurate zoned heat for any room in which a TRV is installed. This not only increases comfort, but can save 5 to 15 percent on energy use per TRV, depending on which and how many rooms you zone. The most efficient use is to zone only those rooms requiring customized control from other rooms in the same zone. Upstairs, for instance, you might use a TRV to keep a baby's room or bathroom warmer than the other rooms on the floor. Downstairs, you could call extra heat to a home office you use in the daytime, leaving the empty rooms cool. A TRV can also be used to cut heat flow to a room that doesn't need it, such as a family room heated by a wood stove or high solar gain, or a spare bedroom that usually sits empty.

TRVs cost from $15 to $50, depending on manufacturer, type (wax versus vapor), and extra features such as remote sensors or control dials. Installation cost will vary depending on your system type and what your plumber charges. You might pay $30 or $40 in labor to add a TRV to one radiator loop in a monoflo system, or $200 to $300 to add a bypass pipe and TRV to a series-loop system. At the lower end of the scale, you will usually recoup your investment within one to three years. At the higher end, it might take five or ten. Either way, you will be more comfortable in the meantime. PS

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the first to meet BOCA requirements—as well as other code standards—on kitchen faucets with removable spouts. —*Marcelle M. Soviero*

Estimating energy use

Computer models can help architects, builders, and researchers predict how a house or building will use energy. But they aren't always perfect. That's because models, while they are mathematically correct, may not account for the way the building is actually constructed, says Doug Balcomb, a principal engineer at the National Renewable Energy Laboratory in Golden, Colo.

In a joint effort with the Colorado State University in Fort Collins, energy-lab researchers will fine-tune a performance test called Short-Term Energy Monitoring (STEM). "We will try to reconcile what we have observed in a building with how the model predicted it should respond," says Balcomb.

In the past, that wasn't possible: "You could observe that a building is using less heat than you thought it should based on the model," says Balcomb, but exactly what factors had improved energy performance couldn't be determined. So, "We've come up with a way to uniquely separate [such factors as] insulation, solar gain, and building-mass effects," adds Balcomb.

Originally developed for houses, the revised model will be able to predict energy performance of large buildings as well as take into account the complex effects of various heating, ventilation, and air-conditioning systems, which the previous version of STEM couldn't do. By the end of the two-year project, "We'll end up with the capability to deal with a large variety of buildings," says Balcomb.

Safer sawing

A new line of Craftsman-brand ten-inch radial-arm saws available this month combines updated versions of the favorite features of older saws with an impressively effective blade-guard system—so effective that the maker, Emerson, is offering the design to its competitors.

Several safety mechanisms work together to protect the user: In the blade's rear-most position, its bottom half is covered by a clear-plastic lower guard that rests on the table. A trigger on the saw handle is squeezed to raise the guard at the start of a crosscut. The guard protects against contact with the hazardous out-feed side of the blade during ripping and prevents wrong-way feed.

A hold-down at the rear of the guard is lowered to just clear the top of the workpiece for ripping; this stops in-feed of the blade, keeps the workpiece from fluttering, and deflects sawdust. A riving knife is lowered to the table for ripping; by keeping the kerf open, it reduces kickback risk. When lowered for crosscutting, the

A new radial-arm saw has a blade-guard system so effective that the manufacturer is making the design available to competitors.

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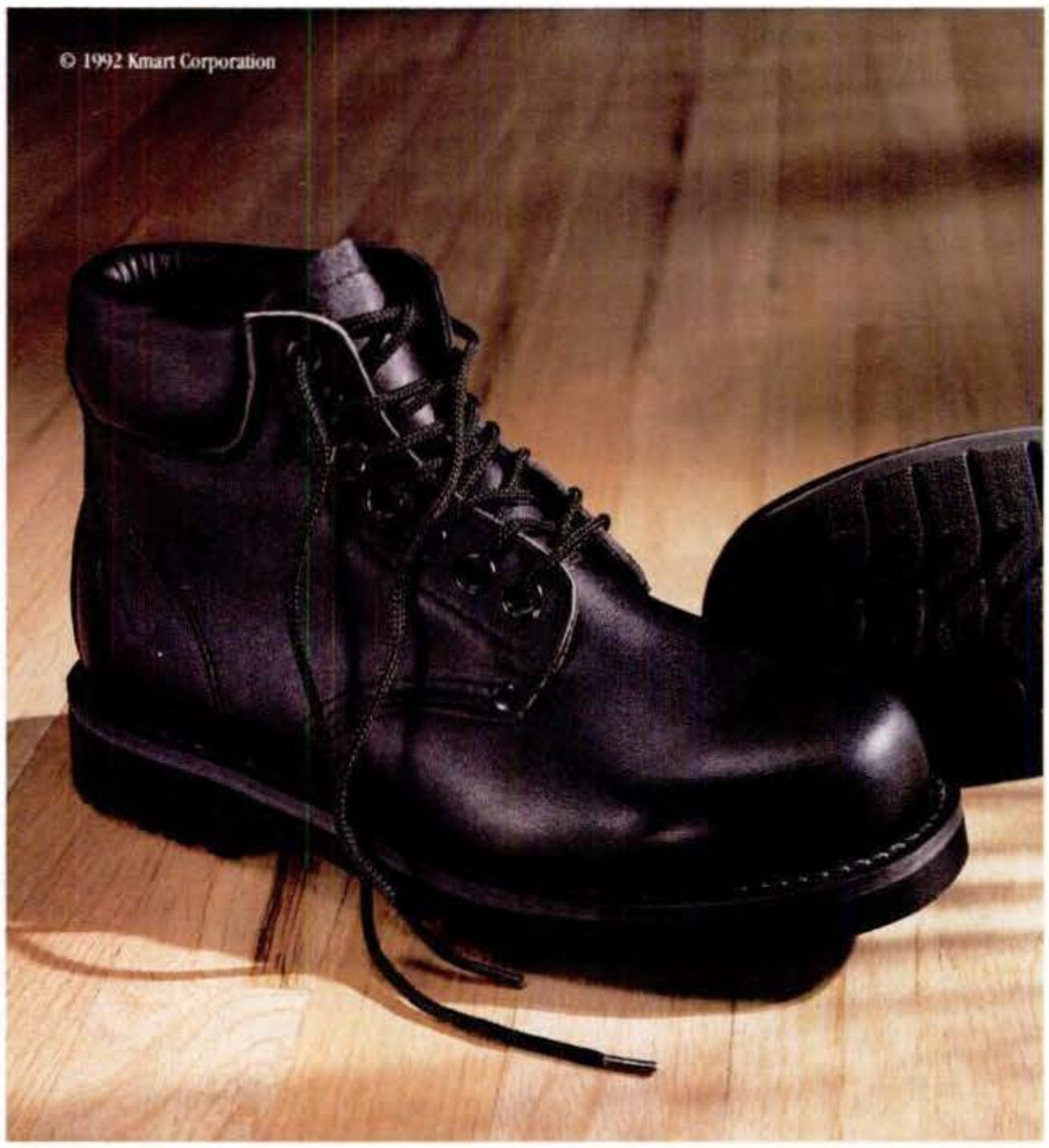

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riving knife also acts as a barrier to the leading edge of the blade. The blade is still exposed during bevel cutting, however.

The saws, models 19622 and 19632, cost about $500. The 19622 has a $2^{1}/_{2}$-horsepower motor; the 19632, a $2^{3}/_{4}$-hp motor. Both saws cut three inches deep at 90 degrees and $2^{1}/_{4}$ inches at 45 degrees. And both also come with sturdy leg sets and 40-inch-by-27-inch particle-board tables.—*Phil McCafferty*

Flame as forecaster

For the 11 million American homeowners who use oil heat, a patented device that monitors flame brightness could detect potential system problems far earlier, saving energy.

Developed by Thomas Butcher, Philip Cerniglia, and Roger McDonald at Brookhaven National Laboratory in Upton, N.Y., the Flame Quality Indicator uses a cadmium sulfide photoconductor to determine when flame brightness falls outside of a preset range.

"It compares flame brightness with the set point when it was originally tuned," explains Butcher. "If the flame is different, then something has changed, and it [the burner] ought to be looked at. It's that simple." Flame-intensity variations can indicate that there is not enough—or too much—combustion air in the oil burner. In either case, efficiency is reduced.

Because it monitors the flame, the device can detect problems weeks or months before an oil burner's primary control would shut down a system because it didn't detect a flame. If this happens, the lights on the sensor's display would turn from green to red.

Butcher says such monitors have been attempted before. "Others have looked at optical controls for very large-scale industrial utility boilers, but the variable firing rates made it too difficult," he says. "In a residential system, every time the burner fires, the flame ought to look exactly the same."

Without such a monitor, "the average system will degrade in performance by about 5 percent over a few years. This will prevent that degradation," keeping efficiency up, says Butcher.

Developed with funding from the Department of Energy, the monitor will be field-tested by several manufacturers this winter. It could become available in two or three years, says Butcher, and cost less than $50. If it were built into control systems by manufacturers, that cost could be reduced to as little as $5, he adds.

Garbage to "wood"

The Research Institute of Wood Products in Balabanov, near Moscow, has developed a new, unique method of producing structural beams from waste materials. The resulting beams are half the cost of wood.

The basic materials of the beams are wood shavings, wood scraps, and organic refuse, such as sunflower-seed shells, rice hulls, wheat chaff, and even fallen leaves. These are mixed in carefully controlled proportions with magnesite, an inexpensive material that acts like a cement, in a solution containing cotton fibers.

The material is kept in a special container at a fixed temperature, and then fed to an extruder. A rotor, similar to one found in a meat grinder, forces the mixture through the die. The material hardens rapidly as it goes through the extruder, and a continuous beam with the desired cross-section is produced. The finished beam can then be cut with standard wood-cutting tools.

The equipment's productivity depends on the quality of the raw materials and the power of the extruder. Experimental machines built so far have been able to produce up to three yards of beam per minute. The resulting beams are also fire-resistant.—*Yuri Egorov*

Heavy-metal tester

Chemists at Tufts University in Medford, Mass., have developed a portable water-tester that can detect trace levels of hazardous heavy metals such as lead, cadmium, zinc, copper, or nickel. Testing water usually requires time-consuming analysis in a laboratory. The new device will make it possible to quickly assess water contaminants on site.

Developed by Samuel P. Kounaves, assistant professor of chemistry, and doctoral students Wen Deng and Zhaohui Liu, the sensor relies on the same principles found in electroplating. "The basics of this technique go back 50 years," says Kounaves. He says his team has miniaturized the process and used a computer-controlled electrochemical technique so that the analysis can be performed on-site with no added electrolyte or deoxygenation.

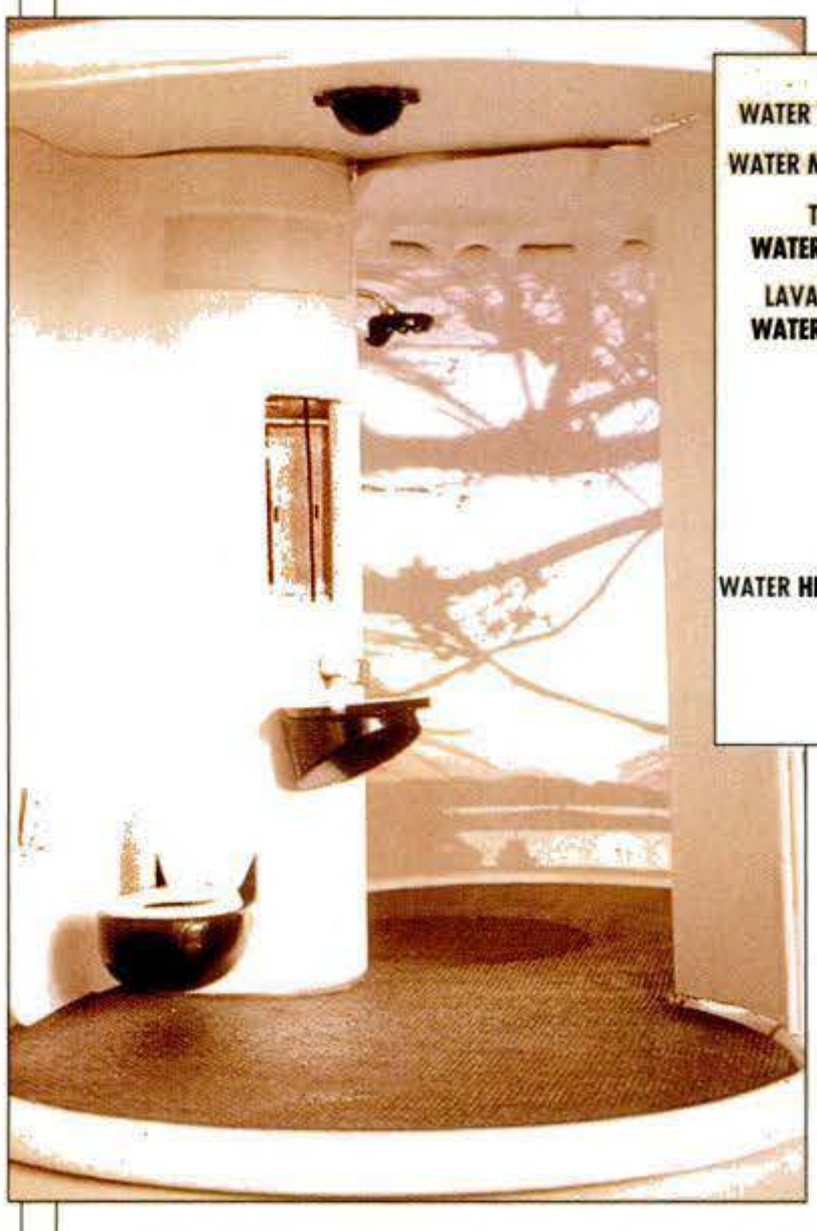
The device uses a mercury-coated iridium disc just ten microns ($^{1}/_{100}$ millimeter) in diameter. "When you apply

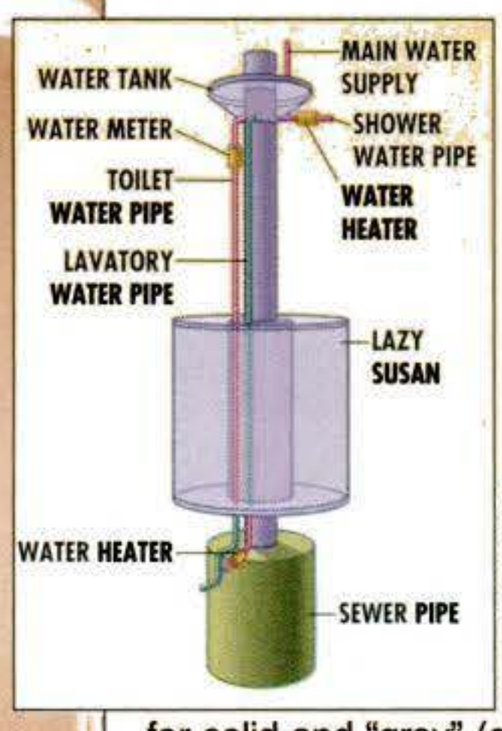
ALL-IN-ONE WATER CLOSET

Daniel Peralta's concept solves the problem of morning battles for bathroom space: His compact design uses cylinders to allow for multiple users.

In the design concept, developed for Peralta's senior project at the Philadelphia College of Art and Design, a person who is in the shower could, for example, shave or brush his teeth while someone on the other side of the bath is using the cabinet (see illustrations).

Within the shell of two cylinders that are wedded as one, the lavatory/toilet and shower areas can be separated into private compartments. Between them, a much smaller cylinder, two feet by eight feet, houses a Lazy Susan cabinet with a non-fogging revolving mirror. Plumbing for the shower, lavatory, and toilet is centralized in this inner cylinder. There are separate pipes for solid and "gray" (or waste) water and a compartment to store and process sewage.





STEVE STANKIEWICZ

The prefabricated cylindrical bathroom would be easy to transport, and the wall-mounted lavatory and toilet, which Peralta envisions made of lightweight plastic, would be easy to install.—*Dorothy Kelly*

In a concept for bathroom design, several people can use the compact cabinet/sink area at once.

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egative voltage, the metal ions in tion are reduced [or concentrated] the mercury tip," says Kounaves. probe's negative charge is then vly reduced to zero, and the metals he mercury oxidize back to their c form.

ach metal oxidizes at a specific volt-, called the redox potential. "As you from a negative-one volt to zero s, you get a current peak at the re- potential for each metal," says naves, "so in effect you have an trochemical spectrum." The num- of metal atoms converted back into s (measured as current or charge) is ted on a computer screen and used determine metal concentration in water.

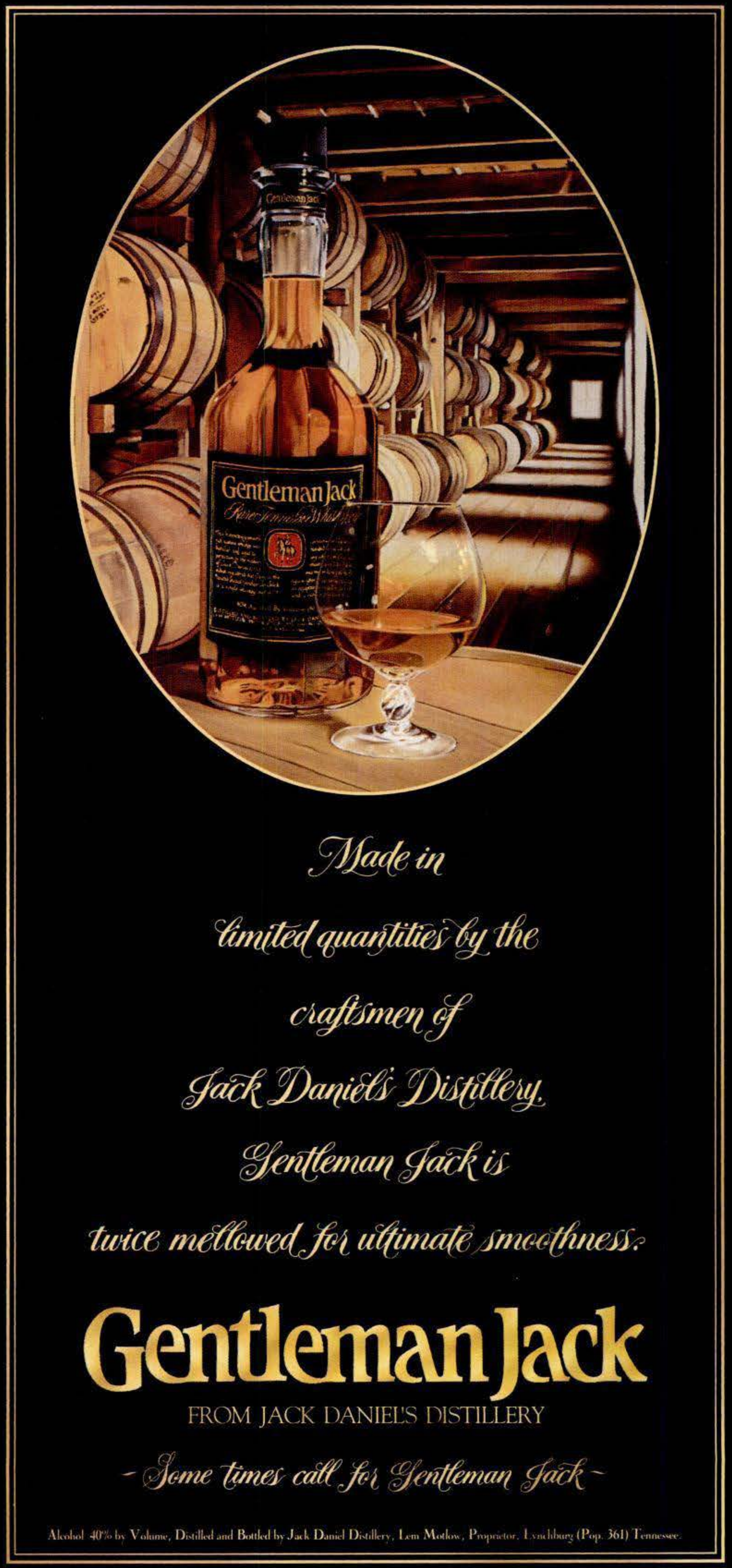
n collaboration with the Center for egrated Systems at Stanford Uni- sity and with funding from the EPA, naves is now developing an inte- ted device about the size of a cigar t will have 20 sensors. "Eventually, hope to have a multisensor array t will rapidly detect many different taminants, not just metals, and w exactly what's in the water, ether it's in a well or a lake or wher- r," adds Kounaves.

tes from home

arbon monoxide, which can leak m faulty home-heating systems, s some 200 people a year, says the nsumer Products Safety Commis- n (CPSC). The agency judges car- -monoxide detectors to be as impor- t to have in homes as smoke ectors. Now the devices will be safer : The CPSC recommends that con- ners purchase new detectors that et voluntary standards by Under- ters Laboratories. Now available, h UL-listed detectors provide a ater safety margin than previous s; most of them cost less than $100.

Getting the lead out . . . of just about rything" is a new free pamphlet m the federal Consumer Informa- n Center that explains the health blems associated with exposure to d, how to avoid such exposure, and ich agencies are working on the blem. CIC, Dept. 614Y, Pueblo, Co- 81009.

While many tub and tile caulks can e 36 to 48 hours to cure, a patented v formulation from Red Devil allows use of bath or shower just three to r hours after application. The ylic-based Quick Protection Formu- forms a protective skin within sec- ds; full curing takes 48 to 72 hours. e caulk contains a mildewcide and be cleaned up with water. PS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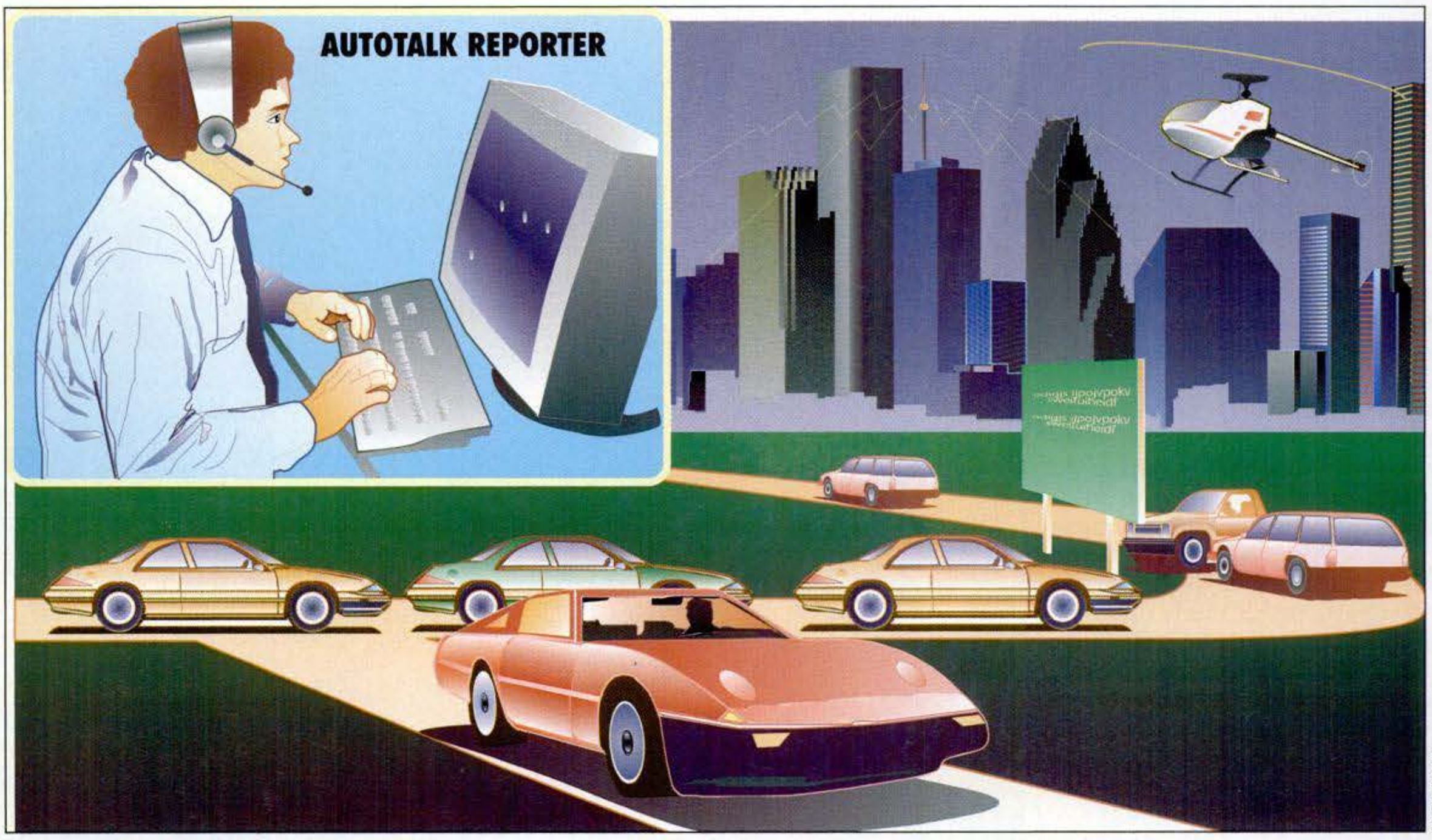

STEVE KARP

Traffic announcers for Autotalk's traffic-reporting service (above) coordinate data for various regions in cities. The reports are broadcast on secondary-audio TV channels. Decoders installed in vehicles (left) tune in local reports, helping drivers to avoid snarls.

All-traffic radio

You're driving to work, scanning the radio dial for a traffic report. But it's too late. You're stuck in a traffic jam, having missed a turnoff that would have avoided the snarl. If only you could press a button and hear the latest traffic alerts when you need them.

Enter Autotalk, from a Santa Clara, Calif., company by the same name. Autotalk's broadcast service, currently available in the Los Angeles and San Francisco Bay areas and planned for Washington, D.C., gathers traffic information from the same sources as commercial radio. The advantage is there's no music, news, or—initially—commercials to delay the information from reaching you. And the company's reports are longer and more frequent than those delivered by AM or FM stations.

Because Autotalk leases the secondary audio program (SAP) channel from a local television station, a car radio set to 530, 1060, or 1590 on the AM dial and equipped with the company's $129 decoder can receive nearly round-the-clock traffic reports. The decoder device unscrambles the TV audio, an FM signal, that's picked up by your car antenna. (If you own a stereo television set, you can hear the same Autotalk broadcasts before leaving home.)

A dashboard-mounted key pad lets you hear all the traffic reports as the announcer cycles through the six regions covered in the Los Angeles area, for example. Or you can program the decoder to filter from one to four regions you're passing through.

Besides traffic reports, the Autotalk device receives the audio portion of all VHF and UHF TV stations in the area. Punching the TV button and the number 7 on the key pad, for instance, tunes in Channel 7 audio. You can also receive weather broadcasts from the National Weather Service.

Autotalk is planning to add sponsors, but company officials promise that commercial announcements won't last more than 5 to 15 seconds at a time—so you won't feel compelled to tune out.—*Michael Antonoff*

Security technology

Enterprising crooks will eventually find ways to foil any lock, forcing researchers to keep pushing the bounds of security science to protect people and property. So visitors stepping on an innocent-looking square of artificial turf at the International Security Conference in New York City last year figured that they had probably triggered a silent alarm—they just didn't know exactly *how*.

The conference's security exhibits bristled with sensors based on radio frequencies, passive and active infrared radiation, sound waves, and fiber-optic cables. The artificial-turf demonstration, for instance, involved light passing through a length of opti-

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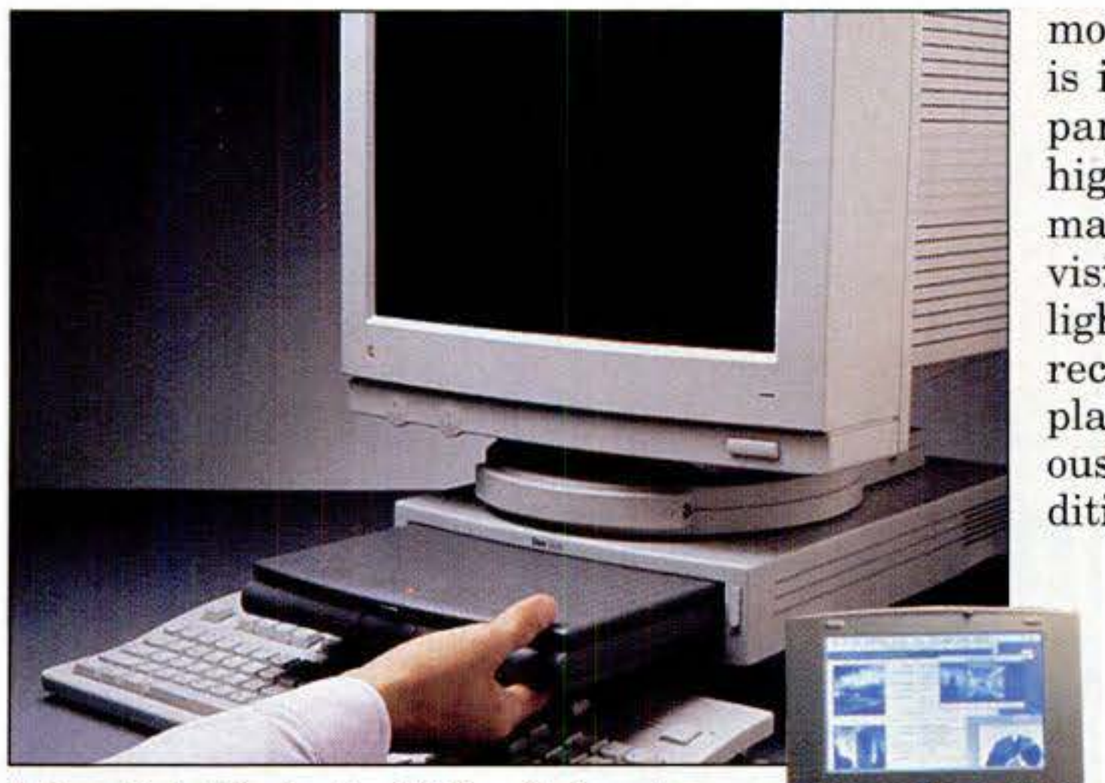
cal fiber. For security installations, long loops of fiber cable are buried in a shallow trench surrounding a protected area. Laser light passing through the cable forms a unique stationary speckle pattern monitored at the control box. If the pattern doesn't move, all is well; but a person or vehicle passing over the fiber compresses the buried cable slightly. That minute distortion alters the speckle pattern and triggers an intrusion signal.

The new fiber sensors differ from older continuity-type fiber-optic sensors that detect only the complete breakage of a slender fiber, explains Douglas LaBarge, manager of field engineering for Stellar Systems of Santa Clara, Calif. But unlike buried coaxial-cable sensors, which monitor a radio-frequency field, fiber-optic sensors can't detect intruders who don't actually step on the cable, he says.

The fiber needs less maintenance, however, and resists jamming and interference from sources such as standing water. That makes it ideal for military bases, nuclear power plants, and other sensitive sites.

Also on exhibit: an example of biometrics—identifying people by measuring physical traits—which was tested at Expo '92 in Seville, Spain ["Techno Expo," May '92]. More than 400,000 season-pass holders to this World's Fair had to press their thumbs against an optical fingerprint-reader before they were admitted to the grounds.

Fairgoers carried a "smart" card from France's Groupe Bull. "Their smart cards stored a mathematical database representing a fingerprint template," explains Randy Fowler, president of Identix of Sunnyvale, Calif. Fowler's company made the print-reading terminals that compared the template on the card with prints scanned from a finger, admitting only those who originally bought the pass.



Automatic docking for Apple's Duo Dock system pulls new Duo notebooks (inset) into place, making connections without cables.

Similar fingerprint readers control rear service doors of many European bank automated teller machines (ATMs). Service technicians' prints are kept at headquarters and records are searched via phone lines whenever anyone wants to gain access. ATM-access controllers are sensitive to the pattern on a particular finger; insert the wrong one into the optical scanner and a silent alarm alerts police. —*Mark Henricks*

LCD-screen camcorder

Tired of being the missing person in home videos? Sharp has introduced a camcorder with a built-in four-inch color liquid-crystal-display (LCD) monitor and remote control. Set the Hi-8mm VL-HL100U on a tripod, position the monitor, and step into the action. The monitor lets you see what's being recorded, and you can aim the camera with the remote control.

An LCD monitor on Sharp's ViewCam can be positioned facing forward or to the rear.

The built-in LCD screen is the main feature of what Sharp calls the LCD ViewCam. Rather than awkwardly peering into a tiny viewfinder, you can comfortably monitor what's being taped on the screen. The camera and screen swivel separately, so the camcorder can be held overhead or at arm's length and you can still easily view the screen. The monitor also rotates 180 degrees to face the same direction as the camera. Digital signal processing helps to stabilize images, compensating for shaky hands when the camcorder is held in odd positions.

Sharp says that the key to fitting a monitor in the camcorder is its new ultrathin LCD panel. The panel has a high-intensity backlight, making the screen image visible even in bright sunlight. You can also review recently shot footage or play prerecorded or previously taped videos. In addition, there's an optional TV tuner.

The 2.8-pound camcorder is currently selling in Japan for about $1,680. Sharp says it will be available in the United States next month. The TV tuner, however, will not be available because of recent import restrictions on LCD televisions.—*Dennis Normile*

Plug-in portables

"Dockable" Macintosh notebook computers, just 1.4 inches thick and weighing 4.2 pounds, lead recent introductions from Apple Computer. The company has also unveiled new units to its line of larger PowerBook models that are more powerful, plus new mid-range desktop Macintoshes and software or operating-system upgrades.

Apple's new Duo 210 and 230 models are compact enough to be called sub-notebooks. Both portable computers, which have nine-inch monochrome displays, plug into the $1,079 desktop Macintosh Duo Dock. (A smaller, more-portable MiniDock is $589.) The docking systems enable you to use color displays or a full-size keyboard, which are both purchased separately. The 210 and faster 230 notebooks have four megabytes of random access memory (RAM), 80- or 120-megabyte hard disks, and cost $2,249 to $2,969.

The newest PowerBook models, the 160 and 180, use 25- and 33-megahertz 68030 processors, respectively. The 180 has a math coprocessor. A video-out feature drives the color displays, such as large projection monitors, with up to 256 colors. The RAM and hard-disk options are similar to those in the Duo line, and prices for the 160s and 180s range from $2,429 to $3,869. A $319 modem card exchanges data at up to 57,600 bits per second (bps), or sends and receives faxes at 9,600 bps.

A large storage bay on desktop Macintosh IIvx and IIvi models accepts CD-ROMs and other optical-disc or tape drives. The IIvx has a 33-megahertz 68030, plus a math coprocessor, and can handle big computing tasks or col-

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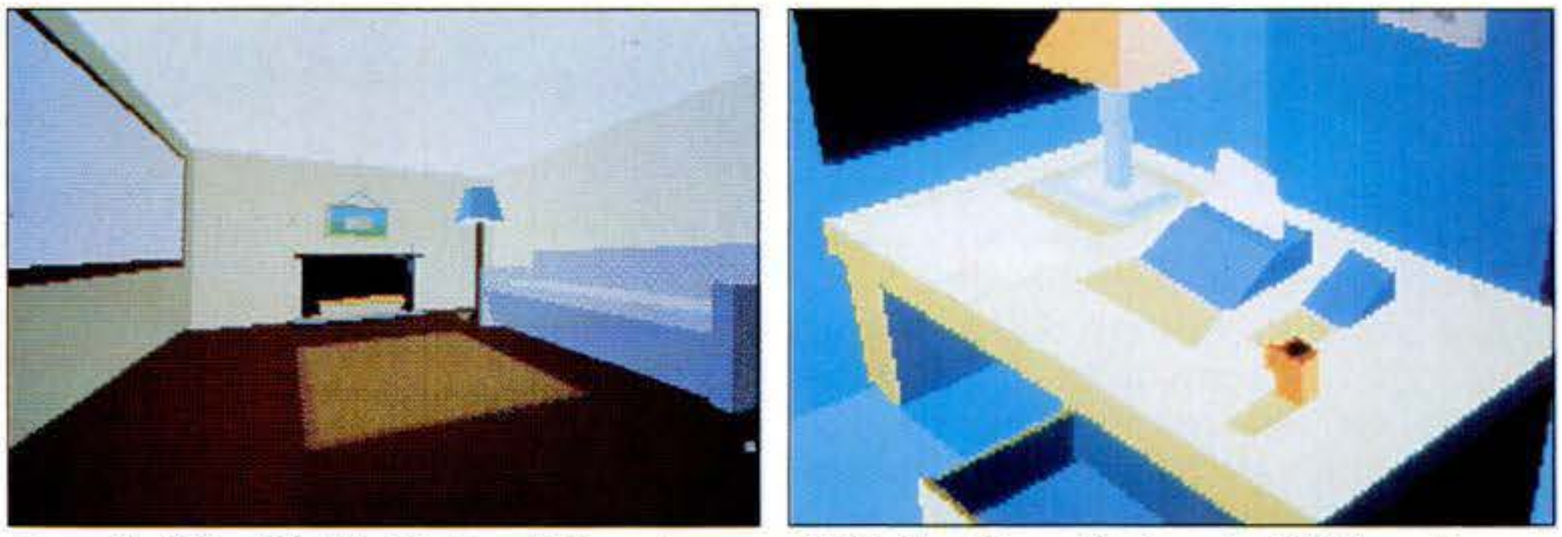


Domark's Virtual Reality Studio, which works on most PCs, is software that creates 3-D (non-stereographic) environments. You can "move" though rooms such as these, picking up objects.

or publishing. Depending on disk configurations, the IIvx costs from $2,949 to $3,219.

QuickTime 1.5 brings enhanced partial-screen animation and multimedia capabilities to Macs. Movielike graphics playback at 15 frames per second is now possible at up to 320 by 240 pixels (picture elements), or 30 frames per second at the original 160 by 120 pixels of QuickTime 1.0. And Apple's new 7.1 operating system makes it easier to introduce software with non-Roman characters to Asian countries. The operating software, which includes QuickTime 1.5, also simplifies accessing type fonts and supporting upgrades for new Macintosh models.

Virtual reality on a PC

The reality of virtual reality is that it takes a lot of computing power to create. The synthetic worlds experienced at arcades or seen at industry exhibits require at least a powerful scientific-

ALL THAT HDTV JAZZ

Can digital high-definition TV broadcasts survive in the real world? They can, judging by a demonstration last September of one format, Advanced Digital HDTV (AD-HDTV), being weighed by a government testing panel. The high-definition signal was carried on UHF Channel 38 in Washington, D.C.

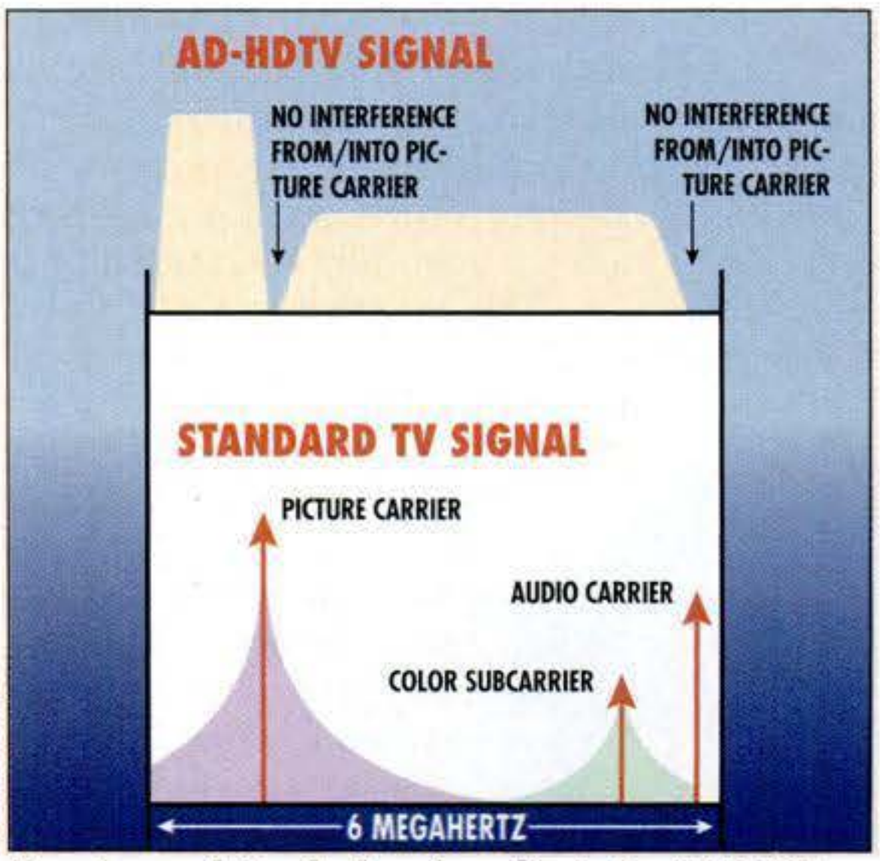
Part of the demonstration contrasted field tests of AD-HDTV broadcasts with standard (analog) TV pictures at distances of 30, 55, and 70 miles from the transmission tower. While the standard signal turned noticeably noisier at 55 miles—the customary outside limit—and dropped out entirely at 70 miles, AD-HDTV quality seemed no different at 70 miles away than it did at 30.

An additional test handicapped the system to show what would happen. When "standard-priority" bits of TV data were removed altogether, leaving only "high-priority" bits, pictures were still tolerable; brief moments of frozen action and touches of blocky distortion could be seen.

HDTV insiders studied the images looking for "motion artifacts"—distortions sometimes visible when movement occurs in digitally processed pictures ["Digital HDTV," Nov. '91]. The sequence of a skateboard-rider zooming through the streets, as viewed on a four-foot-wide Sony monitor that was about 12 feet away, revealed no such glitches.

A unique aspect of this demonstration: lots of footage from the Montreaux Jazz Festival. Excellent stereo sound made the festival a pleasure to see and hear—a useful reminder that HDTV has as much to do with art as it does with industry.

AD-HDTV was developed by the Advanced Television Research Consortium, which includes NBC, the David Sarnoff Research Center, Philips, Thomson, and a new member, Compression Labs. Another leading HDTV contender, the Digital Spectrum Compatible system, was demonstrated last year ["Electronics Newsfront," June '92]. An FCC decision establishing an HDTV standard is expected sometime in 1993, with sets to follow within two years.—*Mark Fleischmann*



Superimposed signals show how dips in the AD-HDTV signal spectrum minimize standard TV interference.

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engineering workstation or its equivalent with larger computers.

Some software and hardware developers, however, have created products for PCs that provide an inkling of what virtual reality is about, although they still lack the realism of higher-end systems. Domark's Virtual Reality Studio, for example, distributed by Accolade Inc. of San Mateo, Calif., is a $90 program that runs on Amigas and low-end IBM-compatibles. The program lets you build worlds inside your computer through which you can roam at will, flying or walking, peering around 3-D objects, or even picking them up and moving them to another spot.

One thing software can't do is overcome the input-output limitations of the typical PC. You probably don't have head-mounted display goggles or an electronic data glove to give you that feeling of being inside and part of your virtual world.

That's changing too, however, and much of the impetus comes from the hobbyist world. Nicholas Lavroff's $22.95 book *Virtual Reality Playhouse* from Waite Press includes a demonstration disk of virtual reality and near-virtual-reality software, plus instructions for wiring a Nintendo Power Glove to fit the serial port on a PC.

The sensation of being visually immersed in virtual reality is a little harder to create. Lavroff tries with a packaged set of red-and-green 3-D glasses. A program displays wireframe objects in two colors on a computer screen. The effect can be startling—a real stereoscopic sense of what virtual reality could be like on your home computer.

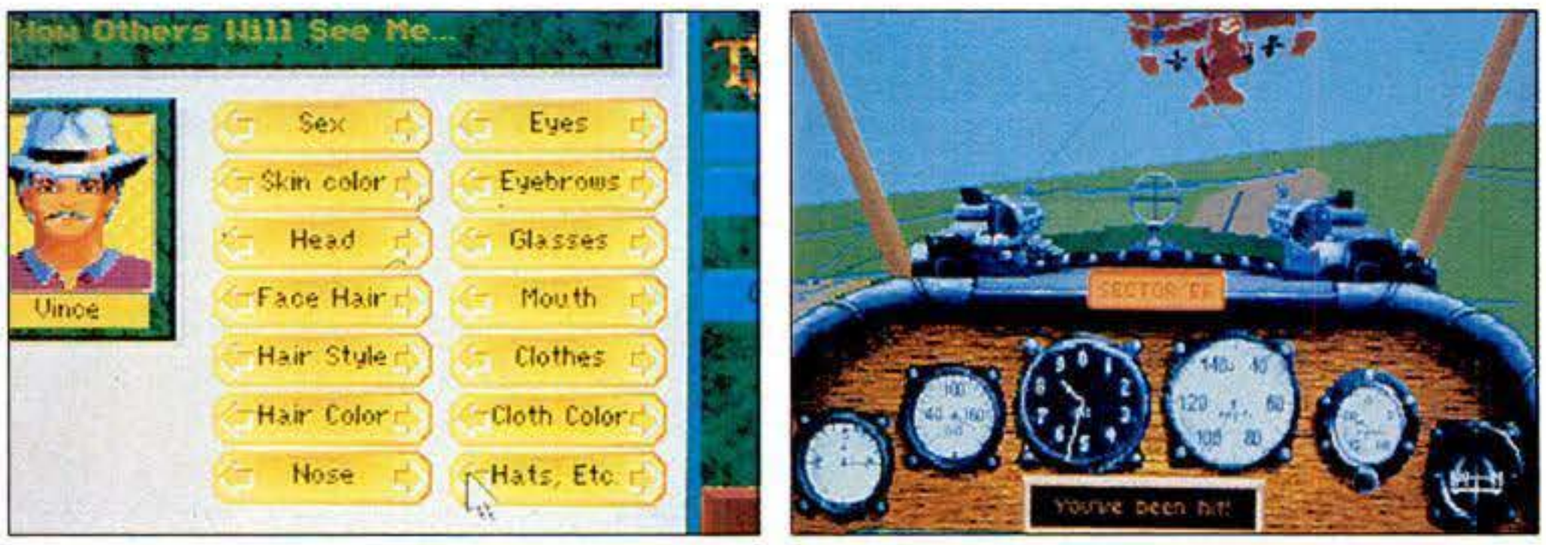
Is it *true* virtual reality, or a watered-down version? Edward Lahood, president of Chicago software developer VREAM Inc., points out there is no hard and fast definition; most vendors tailor their programs to fit a product line. But virtual-reality software, Lahood says, should at least let you work in real-time, see objects in 3-D, "enter" the world and, most important, interact with objects.

"You should not only be able to walk around in the virtual-reality world, but be able to reach out and grab an object and carry it somewhere else," says Lahood. His product costs $1,495 for a software developer's version, $90 for an edition that runs developed programs, and $395 for a similar package that supports reality-inducing input-output devices.

By Lahood's definition, many so-called virtual-reality products for the home are valid. Terra-forming Mars or taking virtual walks around Crater Lake, for example, are both possible with Virtual Reality Laboratories' $130 VistaPro landscape generator software for IBM-compatibles. The program from the San Luis Obispo, Calif., company gives home PCs a larger chunk of reality to roam around in than ever before, virtual or not. —*M. H.*

Cross-country games

The attraction of the Sierra Network, a dial-up, PC-based games network based in Oakhurst, Calif., isn't so much the games themselves as the ability to compete live against people all over the country. You chat with them from your keyboard and watch their responses flash across the screen seconds later. The choices, which include chess, checkers, card games, World War I dogfights, and miniature golf, are familiar fare to arcade and PC-based electronic-game mavens.



An on-line Sierra Network menu (left) lets you create a self-portrait visible to others on the PC-game network. A flight simulator (right) lets you "fly" fighter aircraft, interacting with others.

Using a modem to call a local access number, you find yourself in a "waiting room" along with other players ready to join a game. You check your potential opponents' skill levels and interests and look at their self-portraits. They have the opportunity to learn about you as well.

Before dialing-in the first time, for example, I created a visual presentation for myself by choosing such physical attributes as eye and hair color, shape of face, hairstyle, skin tone, and nose size. I passed over the shirt option, but I did put on glasses. Your on-line persona and the nickname you choose can be as accurate or as outrageous as you like.

You can start one of the games by placing your name in a holding area. Once the requisite number of players have joined, you'll see a countdown displayed. Each player is then prompted to take his or her turn. Clicking the on-screen HI button is a friendly way to acknowledge another player without having to type a lot of keystrokes.

My first on-line game, checkers, seemed as real as if my opponent were sitting across the table—even though he was in another state. Upon jumping two of my pieces, he typed, GOTCHA! The advantage of the computer monitoring the game is that it only allows legal moves. The downside of playing real people is that, unlike machines, they may quit unexpectedly. Wandering blindly around a mazelike game with a woman opponent I had just met, I was suddenly greeted with the message, I'M BORED. She was bailing out TO FIND MORE PEOPLE.

With permission, you can also watch a game that someone is playing. But since each message you type goes to all the players, the Sierra Network rule book advises that you be careful not to reveal confidential information, such as the cards a player is holding.

The software for the Sierra Network needs an IBM-compatible computer with at least 580 kilobytes of free memory, a graphics display, hard disk, and a 2,400-bits-per-second modem, necessary for game-speed interaction.

Although most games play from the keyboard, you will need a mouse for MiniGolf. A joystick and soundboard enhance the action of Red Baron, the flight simulator. Hooking a loudspeaker to the soundboard, in fact, makes your whole desktop vibrate as though you really *are* flying a fighter. Basic membership for the Sierra Network is $12.95 per month for 30 hours of evening and weekend access. Weekday access is $7 an hour. —*M. A.*

Electronics note

•In Washington, D.C., Bell Atlantic and other firms demonstrated experimental hardware that lets you "dial up" digitized, compressed movies from a central source over standard twisted-pair telephone lines. Field tests are slated for next summer. PS

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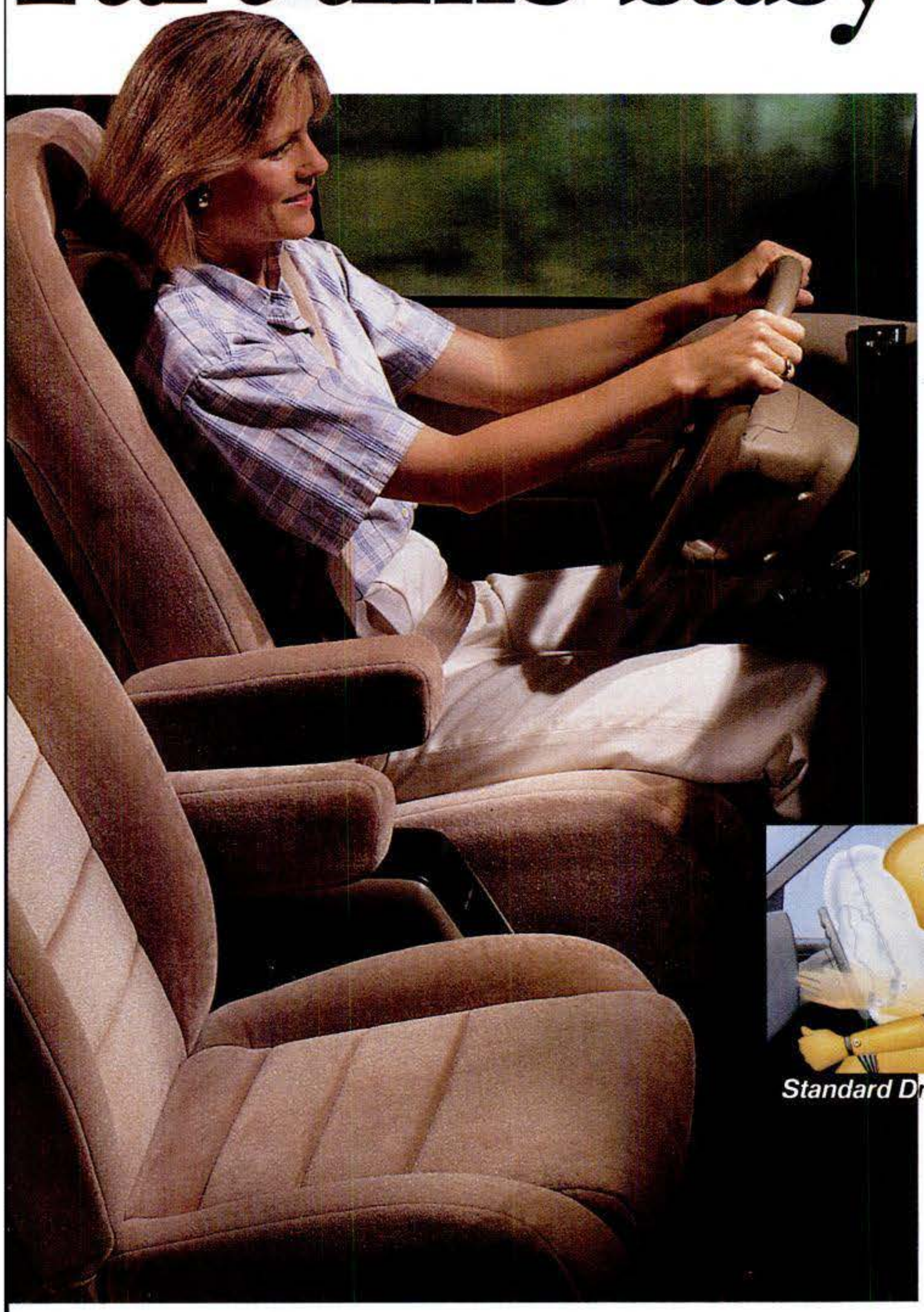

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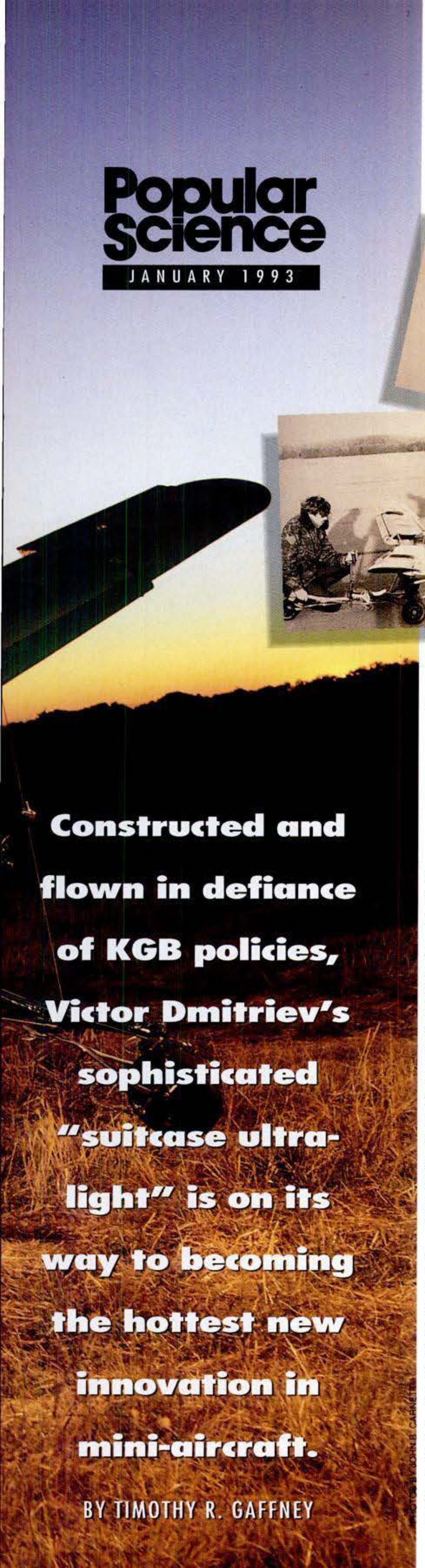
FROM RUSSIA WITH WINGS

Popular Science
JANUARY 1993



Constructed and flown in defiance of KGB policies, Victor Dmitriev's sophisticated "suitcase ultralight" is on its way to becoming the hottest new innovation in mini-aircraft.

BY TIMOTHY R. GAFFNEY

PHOTOS BY JOHN B. CARNETT

Flights of fancy: Victor Dmitriev hoists his 110-pound airplane (facing page); preparing for launch in the pre-*perestroika* times (left); an early check-out flight of prototype X-12 (above); a glider-wing design under construction in the family apartment-cum-hangar (above right).

Try to imagine doing what Victor Dmitriev has done: Driving down a rural road, you get the itch to fly. Scratching the itch is simple—just pull over and unload a large container from the roof of your car. Inside are all the components of a miniature single-place aircraft.

Bolt together the tubular framework, unfold and attach the wings and tail, and in 15 minutes you're ready. A few spins of the two-blade propeller fires up the two-cycle engine. Pull on your helmet, strap into the tiny open-air seat, and aim the craft down the road. Now twist the right handle grip like a motorcycle throttle; the engine's buzz becomes a loud rasp, and you hurtle forward, gaining speed. As the craft reaches 34 mph, pull back gently on the control column. The ground drops away. You're flying.

Now imagine doing it the way Dmitriev had done it for years: sneaking out at night, the aircraft sections concealed in tarps, driving far into the countryside for a brief flight—all the time fearing that someone would see you and report your activities to the KGB.

Forty-seven-year-old Victor Dmitriev was a teacher, truck driver, and aviation enthusiast in what was once the Soviet Union (sometimes referred to as Russia), where building and flying airplanes could get you put in jail. He pored over every bit of available information on American sport planes and taught himself how to design aircraft when the Soviet state considered such knowledge secret. Over the course of 24 years he built 30 aircraft, scrounging materials from the trash, now and then buying real aircraft parts through an illegal underground network. He modified a Czechoslovakian motorcycle engine for an airplane power plant. His design studio, assembly plant, and hangar were all located in the four-room apartment his family shared with two others in Beshckek (formerly Frunze) in Kirghizia, a Minnesota-size republic wedged between Kazakhstan and China.

Only *glasnost, perestroika,* and finally the collapse of the Soviet government allowed Victor's amazing story of innovation, commitment, and daring to emerge: His one-of-a-kind aircraft has begun to draw attention in America's sport-aviation community, and an ultralight kit based on his design is already being offered for sale.

When we visited him last July, he was sweating over the latest version of his machine—what he calls the X-14d—in a large steel hangar at Lodi Airport, a small airfield south of Sacramento, Calif. At the time, his biggest technical hurdle appeared to be matching his airframe design with an inexpensive and readily available engine. He had re-

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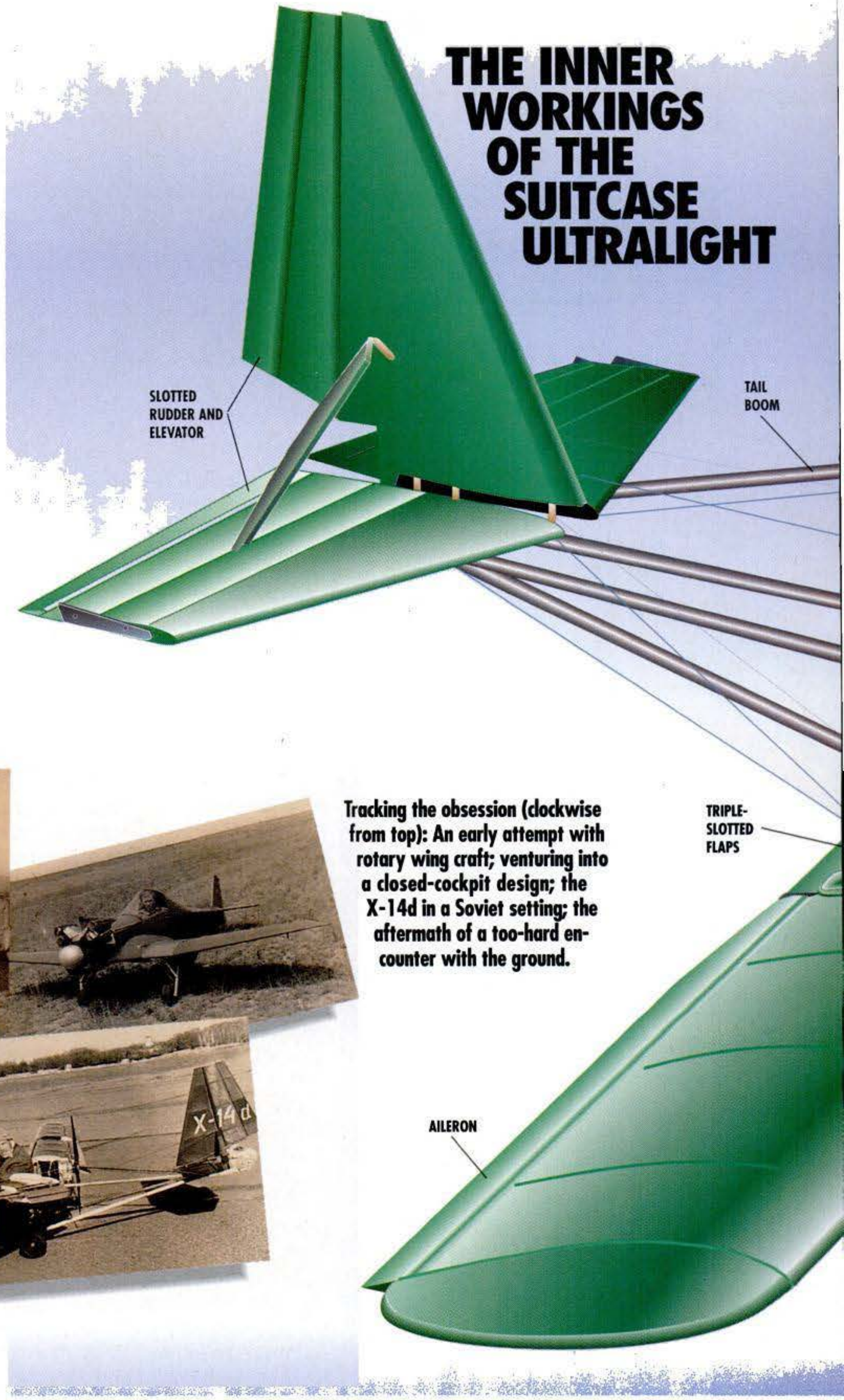
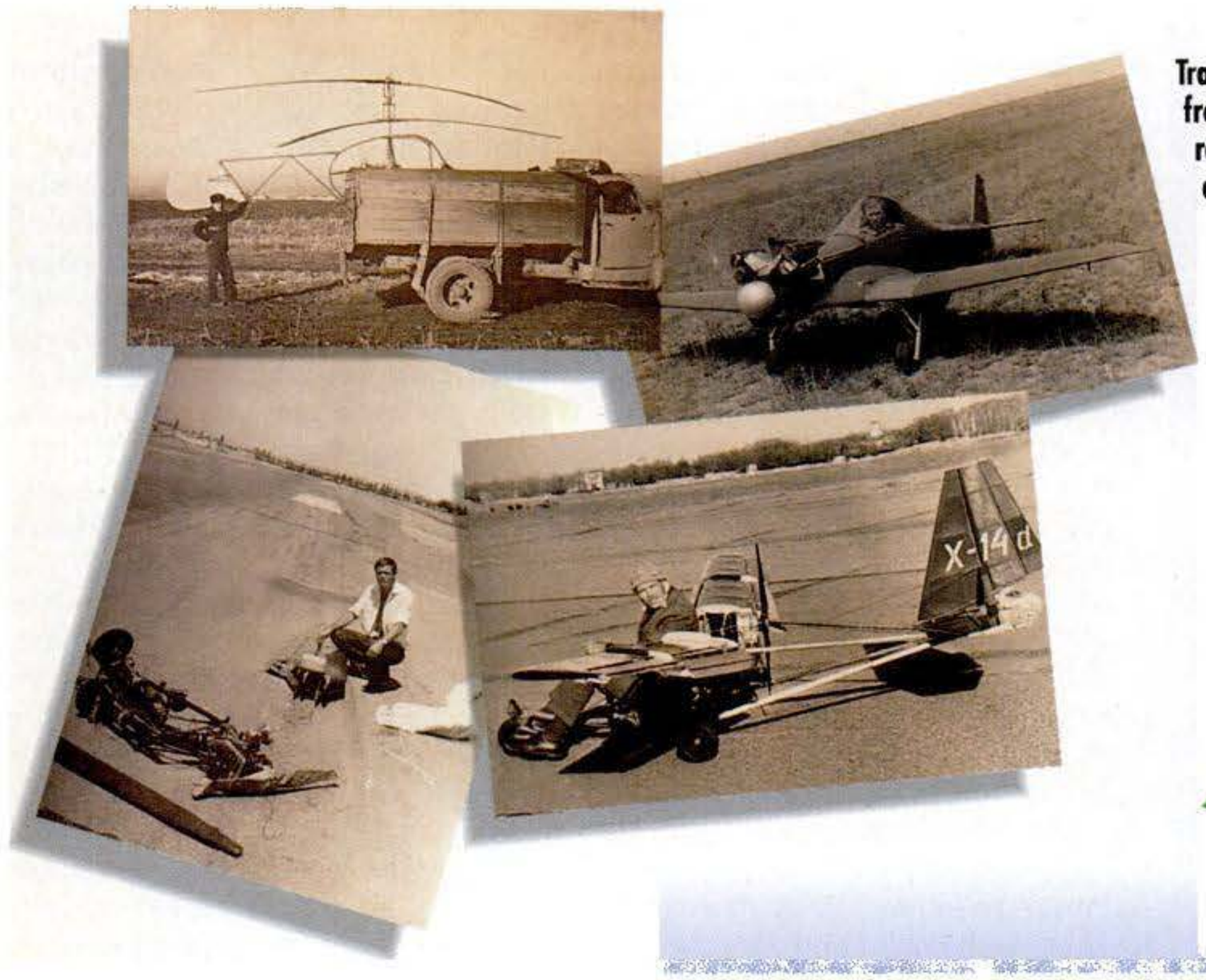
placed his old engine with a power plant commonly used in conventional ultralights, but it proved too heavy and underpowered for his tiny-winged craft.

"Here, I only fly a little, because this plane needs 40, 50 horsepower," he said in halting English. He gestured to the new motor bolted to his airframe. "This, 24 horsepower."

He admitted it achieved only a brief hop off the runway in California. On the other hand, his original engine had a nasty tendency to quit in mid-flight; steel tubes holding the main wheels bear the scars of repeated welding, evidence of many hard landings. Unable to demonstrate its airworthiness for us, the best evidence of the plane's potential is found in the photos and films of flights he had made in Kirghizia.

What makes the X-14d different from other ultralights? Evolved from hang gliders, most ultralights have large, sail-like wings that allow a pilot to fly low and slow. A few are miniature airplanes, complete with enclosed cockpits and fuselages, considered ultralights only because they meet the federal aviation requirements: weight not more than 254 pounds (not counting floats or emergency parachutes), fuel capacity not more than five gallons, a maximum level speed of 63 mph, and a stall speed—the speed at which an aircraft loses the ability to fly—of 27 mph. The allure of the ultralight is obvious: An ultralight flier isn't required to hold a pilot's license or meet rigorous FAA requirements for expensive scheduled inspections and maintenance.





Tracking the obsession (clockwise from top): An early attempt with rotary wing craft; venturing into a closed-cockpit design; the X-14d in a Soviet setting; the aftermath of a too-hard encounter with the ground.

Dmitriev's airplane is neither an outgrowth of a hang glider nor an enclosed-cockpit design. First, it's incredibly tiny—only 10.9 feet long, 16.4 feet in wingspan, and four feet high at the tail. Its wing area is only 18.9 square feet. It's light, even by ultralight standards—110 pounds, as Dmitriev had it outfitted in July. Compare this with a typical well-known ultralight, the Quicksilver MX Sport, produced by Quicksilver Enterprises of Temecula, Calif. Quicksilver's model is 18.1 feet long, 28 feet in wingspan and 8.1 feet high. Its wing area totals 156 square feet, and its empty weight just brushes the 254-pound weight maximum.

But Dmitriev's diminutive craft is most striking in its use of big-airplane features to get maximum performance from its flying surfaces. Its wing has airliner-style flaps and leading-edge slats, giving it more lift and thereby reducing takeoff and landing speeds. A slight but noticeable forward sweep to the wing makes it more controllable at low speeds. And extra joints in the elevators and rudder increase the effectiveness of their small surfaces.

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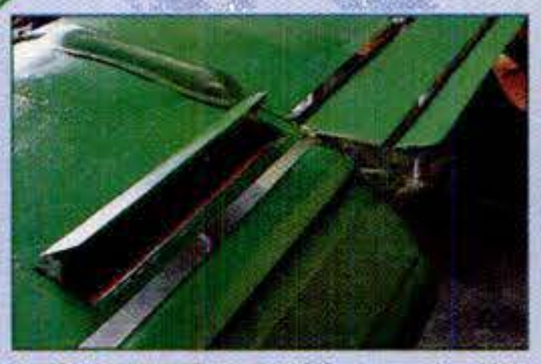
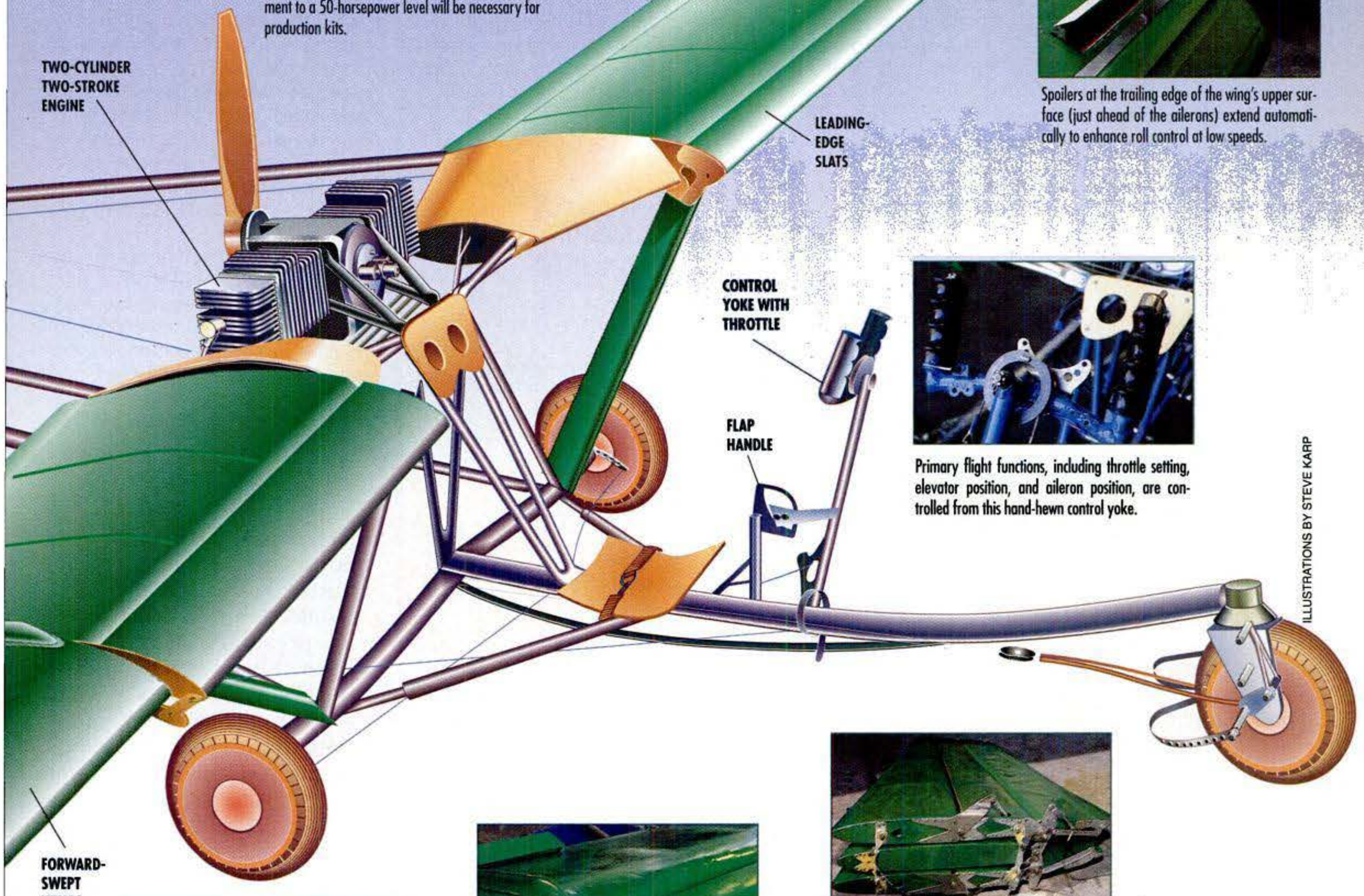
To date, the available two-cylinder two-stroke ultralight engines have proven inadequate. Development to a 50-horsepower level will be necessary for production kits.



Spoilers at the trailing edge of the wing's upper surface (just ahead of the ailerons) extend automatically to enhance roll control at low speeds.



Primary flight functions, including throttle setting, elevator position, and aileron position, are controlled from this hand-hewn control yoke.

ILLUSTRATIONS BY STEVE KARP

A distinct forward angle of the wings enhances the X-14d's low-speed controllability by modifying the wing's stall characteristics.

Leading-edge slats along the front of the wing are lift-enhancing devices that allow slower takeoff and landing speeds; along with the flaps, they are retracted in actual flight.

Folding, detachable wing sections are key to the rather appealing compactness—and ultimately the portability—of the "suitcase ultralight" design.

Seated forward of the wing, with legs nearly straight ahead, the pilot has an unimpeded view, though his ears are just inches from the engine din.

It all comes apart and folds up for storage. Each wing section detaches and then folds in half, the tail group comes off and folds, and even the aluminum tubes connecting the tail section are designed to telescope. The result is a package you can store in a closet, rightfully earning it the nickname of "suitcase ultralight."

To Lodi Airport mechanic John Sherrill, portability is the essence of ultralight aviation. "I initially got into ultralights because I wanted something I could stick in my car or put on top of my car and go out and fly," he said as he watched Dmitriev assemble his machine. "I was really disillusioned when I bought my first ultralight and had to keep it in a hangar."

Dmitriev didn't just dream up the X-14d. As its designation implies, he built a whole series of tiny X-planes over the years. "I built very many wings," he said. "Without flaps. With one flap. With two flaps. With three flaps."

Always modest, he added, "I have of course very many mistakes. Yes, yes. I have very many engine off in air. Yes. I have crashed. Yes, yes."

That Dmitriev lived to tell about his failures is amazing. In a system that only bestowed pilot's wings in government-run academies, Dmitriev had to teach himself to fly. He knew how dangerous it was: Every year, he said, he

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FULL-SCALE CONTROL SURFACES

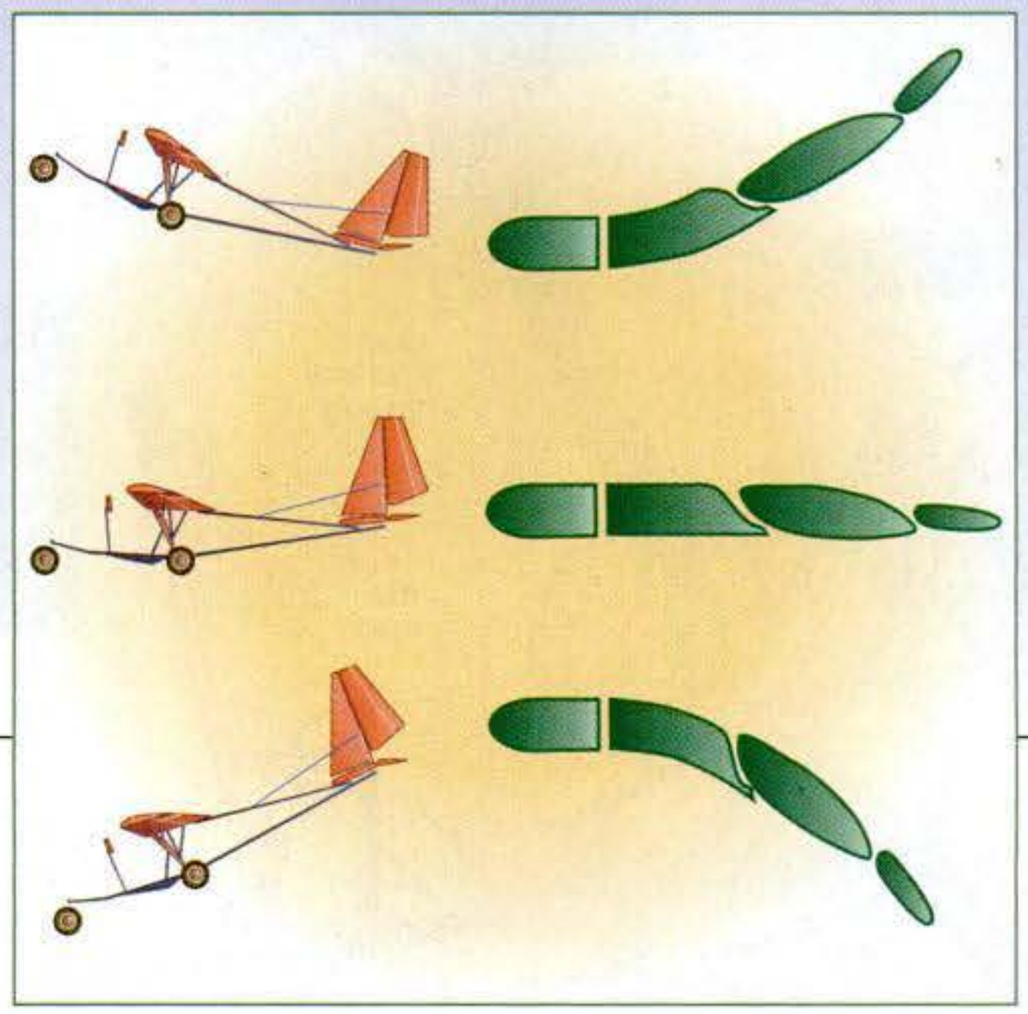
Victor Dmitriev's lilliputian ultralight stands out because of its enormous potential for cut-and-thrust maneuverability. Movable aerodynamic panels—well beyond what's normally employed on bare-basics ultralights—graduate it from the hang-glider league all the way up to a true sport flying machine.

Just like a 350-seat airliner, Dmitriev's design uses flaps and slats to magnify the lift of the wing by effectively increasing the wing's curvature. The X-14d's leading-edge slat and triple-slotted flaps take this idea to the extreme. Controlled by a single mechanical lever on the pilot's left side, the flaps and slats extend and retract in unison. Fully extended, they greatly magnify the lift of the X-14d's tiny wings and reduce the speed needed to get airborne. They also allow a slower landing. On the down side, flaps also increase drag, so they're retracted into the wing structure for cruising.

Similar slotted surfaces are evident at the tail, but their functions are different. Horizontal elevators at the rear deflect the air passing over them, controlling the airplane's pitch axis, or the amount its nose points up or down; Dmitriev added joints in the elevators to increase their effectiveness without increasing their size (see illustration). The upright rudder, which controls yaw axis (side-to-side movement) gets a similar segmented treatment.

Another trick Dmitriev employed was the forward-swept wing. Forward-swept wings can enhance low-speed controllability by forcing the stall—the point at which the airflow over the wing becomes turbulent and stops providing lift—to start at the root of the wing instead of the tip. This keeps the ailerons effective down to the speed at which the entire wing stalls. Forward-swept wings have been used on a few planes before, notably the German Hansajet corporate plane and the supersonic Grumman X-29, an Air Force/ NASA research jet.

Aiding the X-14d's ailerons are spoilers, or short slats, that rise from the upper surface of the wing just forward of the ailerons. In Dmitriev's design, each spoiler extends automatically when the aileron behind it is fully deflected, enhancing roll control at low speed. —*T. R. G.*



heard of people dying at the controls of their experimental machines.

He had one big advantage, though: His father, Pavel Nikolaevich Dmitriev, was a Soviet military officer, pilot, and engineer who taught at the Moscow Military Aviation Academy. He took Victor flying as a child and infused in him an interest in flight. Victor soaked up his father's military literature on the principles of flight and aircraft design.

But Dmitriev's father retired from the military before Victor was old enough to launch his own aviation career, and his father's past connections weren't enough to penetrate a system where connections meant everything. He applied several times to special vocational schools and college but was never invited to take an entrance exam. Later, he said, he held a job in a small vocational school and learned that nearly all the students were relatives or friends of school officials.

Victor's first attempt to build an airplane, in 1968, used a version of the Rogallo wing, a triangular kitelike device popular with early hang gliders. It didn't work, but he was undeterred. In 1970, he got an aircraft off the ground; in 1979, he flew his first circle.

He concentrated on small aircraft "only because I took into consideration my own possibilities—materials I could get, finances, the space I had," he said through an interpreter. Dmitriev made contact with other closet airmen who helped one another. He said they sometimes sold aircraft parts under the table, and when he couldn't find parts, he made them. He carved his own propellers with hand tools. He covered the wing and tail surfaces with parachute fabric, then shellacked and painted it for a smooth, drum-tight surface. He made lightweight wing struts by shaping pieces of wood, cutting them in half, hollowing them out, and gluing them back together, and then epoxying on a layer of fiberglass cloth.

Not all of his challenges were technical. In 1975, KGB officers showed up at his door and interrogated him about his flying. "It was not prohibited officially, but they didn't like the activity," Dmitriev recalled. "Maybe they were afraid people could fly abroad and would cross the border. Also, they did not want anyone to own property, and an airplane is considered property." The KGB officers told him he could continue his hobby of building aircraft, but they took his name and warned him not to attempt to fly.

Dmitriev flew anyway. He spirited his inventions away at night and put them together far out in the rural countryside, away from prying eyes. It became easier in the years leading to *perestroika* because economic and social conditions in the Soviet Union were deteriorating, and authorities certainly had much more pressing things to worry about than some eccentric aviation enthusiast.

Under the rule of former Soviet president Mikhail Gorbachev, a new era of openness flourished. Soviet newspapers began writing about Dmitriev's work, and officials invited him to display his aircraft at military air shows. His work surfaced in the West in 1990 when the magazine *Aviation Week & Space Technology* published a photo of his machine. In 1991, he sent photographs of the X-14d in flight to the Experimental Aircraft Association (EAA) in Oshkosh, Wis., which published them in the magazine it sends to its members.

Still, Dmitriev's greatest challenge in bringing his amazing aircraft to market may well lie in coming to grips with good old American capitalism.

Dmitriev brought his wife, Ludmila, and six-year-old daughter, Julia, to the United States in April as guests of John Kupka, a dealer of used aircraft based at Lodi Airport. Hoping to manufacture and sell ultralight kits with Kupka, Dmitriev dreamed of a new life here and a career in American aviation. That dream was shattered, Dmitriev said in September, when Kupka offered him an agreement that demanded all rights to his designs in exchange for help in getting an alien residency "green" card—and no percentage of any profits. "I don't want business with Kupka," Dmitriev said bitterly as his family packed to return to Kirghizia.

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But Dmitriev didn't leave the United States before closing a deal with another American entrepreneur, Rienk Ayers of Santa Barbara, Calif., to redesign and sell the ultralight. Dmitriev still surrendered the rights to his design, but Ayers has agreed to pay him $20,000 in cash and 10 percent of profits from kit sales, and, of no little importance to Dmitriev, "primary consideration" for any engineering or production employment in the fledgling business. Ironically, Dmitriev may find his own design competing against itself. In September—after Dmitriev had rejected his offer—Kupka still said that he planned to market an aircraft that incorporates many of the design features of Dmitriev's plane, and by November of 1992 he was in fact advertising the kits' availability.

Kupka's plan is to sell the suitcase ultralight (actually two suitcases for the wings and tail section plus a canvas bag for the main structure) in three versions: a derivative of the original design as it appeared at the EAA's annual fly-in at Oshkosh, a true ultralight, and a crop duster version. The original, with design revisions commissioned by Kupka, must be classified as an experimental aircraft because it doesn't conform to the FAA's rules regarding stall speed. Under this classification, a pilot's license is required to fly it.

The wing design of the actual ultralight model has been revised to bring the stall speed into compliance, and the flaps are now combined with the ailerons and run the wing's full span. The design work for these models was not done by Dmitriev, Kupka emphasizes, adding that he doesn't expect Victor to return to the United States. "We don't have any further need for his services, so I don't anticipate that he is going to be back."

As of November, Kupka had no flying model to demonstrate, stating that the prototype components were being revised by design agencies. He claimed that test flights will begin in January 1993, with kit deliveries starting Feb. 1.

Both Ayers and Kupka have quoted prices of around $7,000 for a kit. That's just for the airframe; adding a two-stroke, ultralight engine would raise the total cost to around $10,000 to $12,000.

Still, before any production version of the X-14d is offered to the public, substantial modifications will be needed. Its design is still unproven, its behavior in all areas of the performance "envelope" unexplored. Dmitriev is hardly a test pilot, and he said his longest flight in Kirghizia lasted just 8.5 minutes, when his engine quit. He says the highest he has flown it is 350 feet—much too close to the cold, hard ground for testing a plane's behavior in steep turns or stalls.

The first trick in flight-testing the X-14d will be to get it off the ground. Ayers is confident the X-14d will fly with a good ultralight engine, but he ticked off several changes he plans to make in a kit that will be available through Sreya Aviation (7645 Calle Real, Santa Barbara, Calif. 93117).

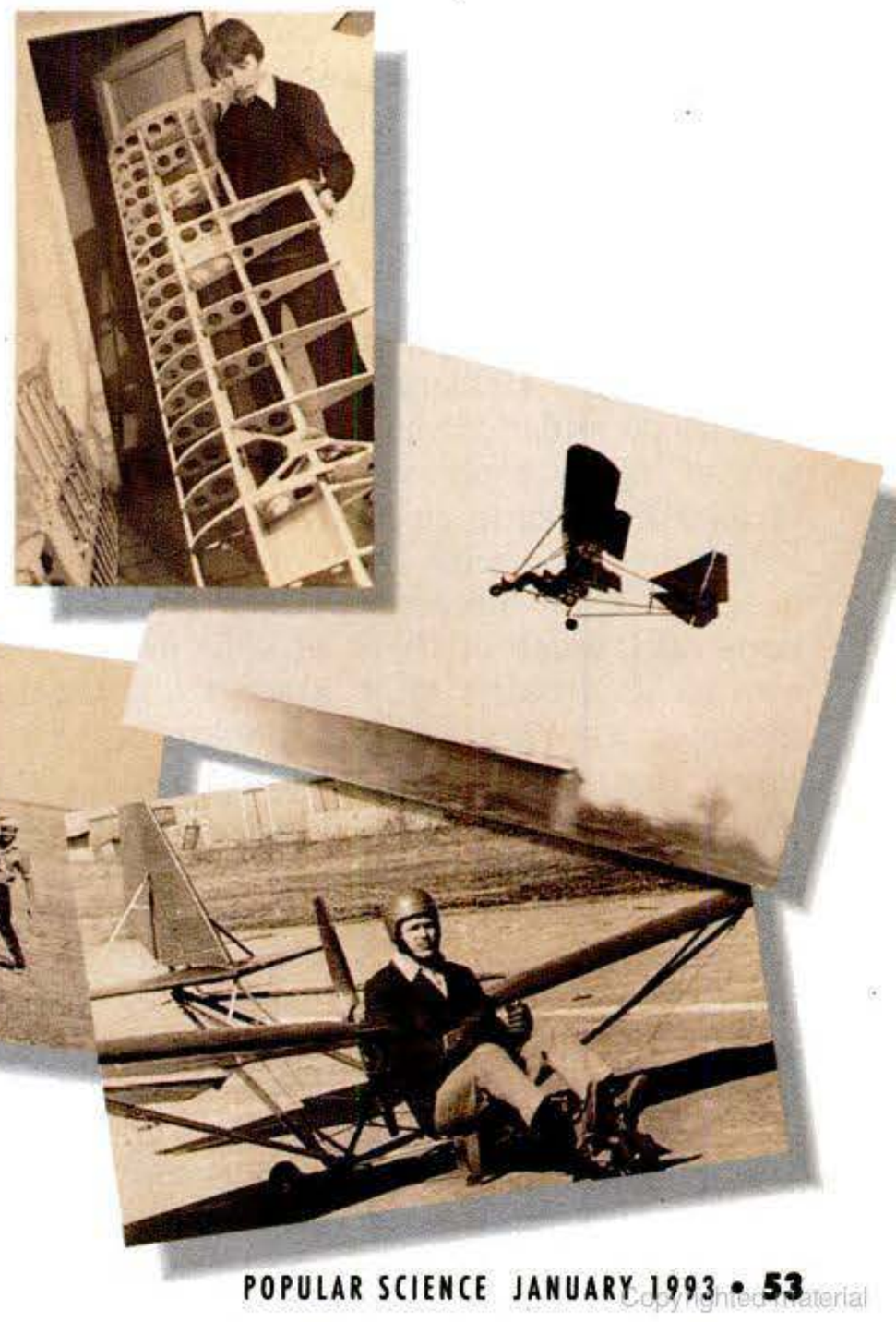
- A rollover cage for crash protection, a small instrument panel, and possibly a windscreen and fabric enclosure. It will also have a ballistic parachute that can pop out in an emergency.
- A high-wing instead of mid-fuselage wing configuration for increased stability.
- More wing area—about 40 square feet—to compensate for a doubling of weight and to reduce the stall speed to meet the 27-mph ultralight limit.
- Longer tail booms to increase the ultralight's length to about 18 feet, which will make it more stable in pitch or nose-up nose-down movements.
- Structural changes for easier assembly. The wing will be straight instead of tapered (although it will keep the sporty forward sweep), and the leading-edge slats may be eliminated. The wings could be made with foam cores and fiberglass skins, a construction method used in a variety of homebuilt planes. Fiberglass is also likely to replace the handcrafted wooden parts.
- A variety of power plants and modification kits to allow builders to construct a light aircraft capable of speeds of up to 120 mph.

Ayers admits his plans hinge on raising capital to produce the kits. He says he hopes to produce ten kits for testing by early spring and show them at summer fly-ins and shows.

Least clear of all is Dmitriev's next step. He had hoped to avoid returning to Kirghizia because he feared for his family's safety. He said the sinking economy and deteriorating government control have been drawing bandits out of the mountains into cities like Beshckek. And he said there's less tolerance for Russians in Kirghizia, which is closer to Afghanistan than Russia. "It's very dangerous for Russian people to live there," he said.

Ayers may be Dmitriev's last best hope. "I am very intent on helping to arrange his family's return to America as soon as possible," Ayers said a few days after Dmitriev's departure. Ayers admitted he isn't just being a nice guy: "It will be very difficult to proceed too far into this project without his direct input."

In ways he could never have imagined, Dmitriev's little airplane holds the key to his future. PS



Charting the progress (clockwise from top): A wing skeleton under construction in the Dmitriev apartment; an early high-wing prototype; Victor with a nearly current design; the full-cockpit, but still featherweight, X8; a Rogallo-wing study, later abandoned for more conventional wing designs.

HISTORICAL PHOTOGRAPHS FROM THE DMITRIEV ARCHIVE

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STALKING STEALTH VIRUSES

Forget all the hype over Michelangelo. 1993 may be the year that a new breed of less visible but more sophisticated viruses begin to slip into thousands or even millions of PCs.

JOSEPH ULATOWSKI

BY CHRISTOPHER O'MALLEY

Like personal computer users around the world, Greg Buckley heard the warnings about the dreaded Michelangelo "virus," a malicious software program designed to wipe out the contents of an infected PC's hard disk on March 6, the artist's birthday. But unlike most, Buckley, a plumbing contractor in Boynton Beach, Fla., was a victim. He turned on his PC that fateful Friday to find all of his accounting files gone.

But if 1992 was the year Michelangelo pushed computer viruses into the spotlight, 1993 may be the year viruses go under cover. A new generation of highly sophisticated "stealth" viruses has begun circulating among PCs, spreading with little or no evidence of their presence. More ominous still, some of these viruses are mutating strains that alter their makeup as they spread, posing a more insidious threat than fixed viruses such as Michelangelo, Stoned, and Jerusalem.

By definition, computer viruses are clandestine creatures. These programs conceal their instructions inside other software programs, secretly attaching themselves to other files and floppy disks or lodging in the special start-up area of a disk known as the boot sector. Once a program or disk has become "infected" with one of these invisible stowaways, it executes the virus's instructions—some destructive, some merely annoying—without prompting or warning. The virus spreads when an infected program is copied to another computer or an infected disk is read during start-up.

Traditionally, a virus leaves telltale signs of its presence. Many viruses noticeably increase the size of files or reduce the amount of available memory, symptoms that can provide early warnings of an infection. Other viruses make changes to critical start-up areas of a disk that can be inspected for unwanted alterations, such as the "boot record" and "partition table" on IBM PC-compatible systems. And most viruses bear a kind of digital signature—a unique string of software codes that can be easily detected by so-called anti-virus scanning programs, which seek out and remove viruses.

Unlike conventional viruses, however, the newer stealth strains employ a variety of cloaking techniques to make themselves invisible to both the human eye and the electronic scrutiny of anti-virus programs. The longer these viruses remain undetected, the further they can spread and the more damage they can do.

While their camouflaging methods vary, stealth viruses—almost all of

which have been detected since 1990 —employ two basic techniques to avoid detection: getting "under" the operating system and subverting a computer's disk operations to conceal the presence of a virus, and digitally encrypting the virus itself to thwart scanners looking for a familiar signature or pattern.

Disk deceptions are the most common stealth ploys. The 4096 virus, also known as the Frodo or Hundred Years virus, is one prominent example. This virus, which originated in Israel, infects program files (typically files ending with the extension .EXE or .COM) on IBM-compatible PCs. In the process, the virus adds 4,096 bytes to the length of each file. But that increase never shows up on a computer screen; the virus stores the original file-size data at the end of the infected file and summons it whenever the DIR (directory) command requests a list of files, so all files appear to be the original lengths. The 4096 virus also has a number of built-in defenses against disk mapping and debugging programs, making those tools virtually useless in detecting it.

These defenses buy the 4096 virus time to slowly and surreptitiously weave a web of improper links among program and data files, damaging both. The virus also has a trigger date: On or after Sept. 22 of any year (the birthday of Frodo, a character in the *Lord of the Rings* books), the 4096 virus will cause system crashes. A number of other new file-type viruses, including a Bulgarian strain called Dir-2, a German virus called Whale, and a virus of unknown origin known as Crazy Imp, play similar tricks on the DOS file system.

Many viruses that infect the boot, or start-up, areas of a DOS disk have also taken on stealthy sophistication. These boot-type viruses infect the hidden programs a PC reads when it's turned on or restarted, loading themselves into memory before anything else can take place. Ordinarily, a disk-editing or anti-virus program can simply inspect these special disk areas and remove a virus caught nesting there. But some of the latest boot viruses can fool these programs into thinking all is well when the start-up areas are in fact corrupted.

The Joshi virus, probably the most widespread of all stealth viruses to date, infects the boot sector of floppy disks and the partition table of hard disks. But when a program attempts to read these areas, Joshi intercepts the probe and directs it to a copy of the original boot sector or partition table stored on another part of the disk. Joshi, developed in India, is not a particularly malicious virus—every Jan. 5 it displays the message TYPE HAPPY BIRTHDAY JOSHI on the screen and freezes the computer until the user obliges. But some stealth boot viruses, such as NoInt from Canada (a stealth variation of the Stoned virus), can cause file damage or loss as they maneuver around the operating system.

The most formidable virus threat today comes from new "super stealth" strains that combine these hide-and-seek games with complex encryption schemes that conceal, and even dynamically alter, the viral code itself. The technology of digital encryption is not new—businesses often use encryption to protect sensitive data —but it takes on a darker dimension when applied to viruses. Essentially, the encryption process uses a mathematical algorithm and a random-number generator to disguise bytes of binary code (ones and zeros) as a new series of numbers. Most computers have timer or counter chips that can easily generate random numbers, so a virus program simply needs an encryption algorithm and the instructions to use it. Once encrypted, a virus is extremely difficult to detect because its unique signature has been wiped away.

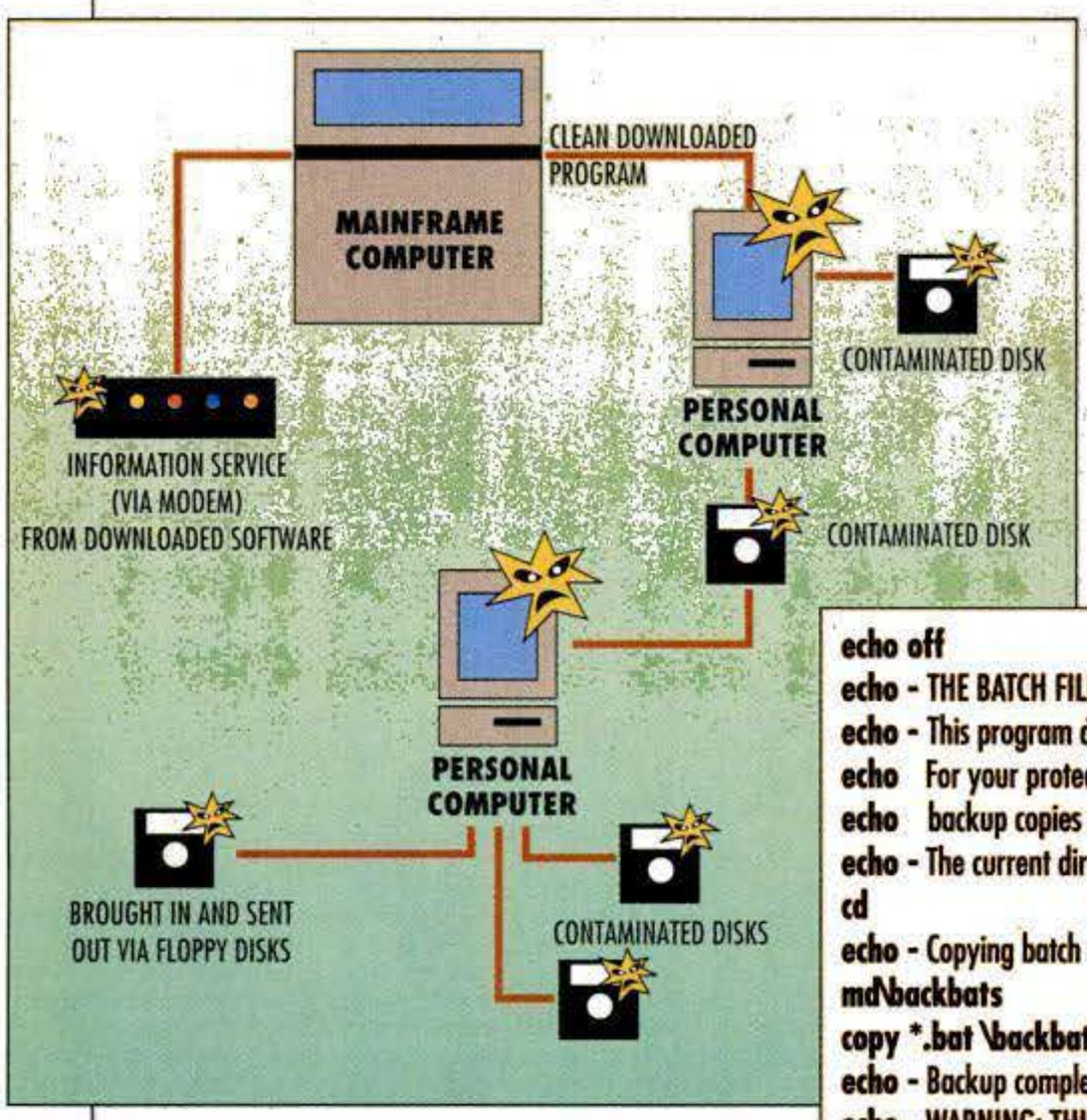
The recently discovered Tequila virus, traced to Switzerland, is one of

HOW A VIRUS WORKS

Computer viruses are programs, or lists of instructions, that embed themselves inside other programs and execute whenever the "host" programs do. What viruses do when executed varies from one virus to the next, but the chief function of most viruses is to "infect," or copy, themselves to other files or floppy disks. A few viruses do nothing but replicate, but most eventually reveal themselves, often triggered by a date or span of time. Some viruses display mischievous messages or induce peculiar behavior, such as causing letters to "fall" to the bottom of the screen. Others are more malicious, damaging data files or erasing programs.

The simple virus program shown here, adapted from an example in *The Computer Virus Handbook* by Richard Levin, is written using MS-DOS's batch file commands and does not have a trigger event or a devious purpose of any kind. But it does show how a virus can quickly spread from file to file. Stripped of its many messages, backup precautions, and input prompts, this virus program boils down to a single line of batch file code: the instruction "for %%f in (*.bat) do copy %%f + bfv.bat," which tells the computer to append a copy of the virus code to every batch file in the current directory. If an infected batch file were to be passed from one user to another, the new user's batch files would become virus carriers as well.

Real-world viruses work their way into files and onto disks in more sophisticated ways, of course. Stealth viruses would take added steps to avoid detection, such as hiding an increase in file size when burrowing into files and randomly encrypting their digital "signature" to fool anti-virus programs.—*C. O.*




```
echo off
echo - THE BATCH FILE VIRUS (BFV.BAT)
echo - This program demonstrates how computer viruses operate.
echo   For your protection, this program will automatically make
echo   backup copies of all batch files in this directory.
echo - The current directory is:
cd
echo - Copying batch files to backup directory called BACKBATS...
md\backbats
copy *.bat \backbats
echo - Backup completed.
echo - WARNING: THIS PROGRAM WILL INFECT ALL BATCH FILES IN
echo   THE CURRENT DIRECTORY! INFECTED BATCH FILES WILL INFECT
echo   OTHER BATCH FILES WHEN RUN!
echo - Press any key to execute the Batch File Virus or press
echo   Control-C to Cancel.
pause > nul
cls
echo - Infecting all batch files in this directory...
ctty nul
for %%f in (*.bat) do copy %%f + bfv.bat
ctty con
```

Computer viruses are lines of code like the ones in this innocuous example (right) that latch onto other program files and run when they do. Viruses spread through online exchanges or, more commonly, via floppy disks passed among PCs (above).

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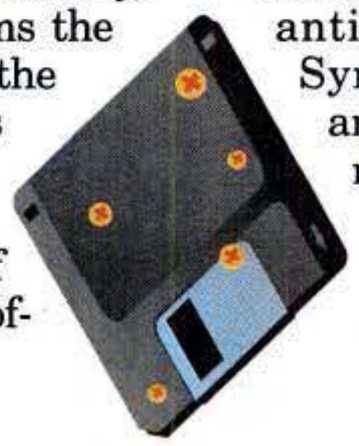
the more common super-stealth strains. Tequila is both a file- and boot-type infector that hides any increases in file sizes and uses a sophisticated encryption method to avoid being detected or disassembled. The Telecom and Holocaust viruses, both from Spain, are similarly encrypted. Tequila and Holocaust can cause errors and possibly damage files; Telecom, which also goes by the name Spanish Telecom-2, will eventually overwrite hard-disk files.

The latest virus-encrypting technology is the Dark Avenger Mutating Engine, a byproduct of the notorious Dark Avenger author (or authors) from Bulgaria (see The Bulgarian Connection). The Mutating Engine is not a virus itself but an elaborate encryption program that can be attached to almost any virus to create a polymorphic virus —a virus that can take many forms. Polymorphic viruses are not only encrypted, they change their encryption frequently so as to never look the same twice. The Mutating Engine is an incredibly efficient encoder, allowing no more than three bytes (out of hundreds of thousands) to remain constant from one encryption to the next. It also tosses in meaningless instructions to further ensure a unique result.

Though the Dark Avenger Mutating Engine was first documented earlier this year, several polymorphic viruses have already been developed with it. None of these Bulgarian viruses are terribly destructive: Pogue plays music between 8 a.m. and 9 a.m., Fear can cause a computer to freeze up when an infected program is run, and Dedicated simply keeps cloning itself. But the potential for more lethal polymorphic viruses is intimidating, and the trend toward nastier viruses is growing.

The Michelangelo virus is a testament to this negative trend. The Stoned virus from which it evolved is believed to be the most prevalent virus in the United States and is certainly one of the most innocuous, flashing YOUR PC IS NOW STONED on the screen when you boot an infected disk. But if Stoned is typical of the prankish mentality behind many viruses of the 1980s, Michelangelo and its wanton destruction may be the prototype for the 1990s.

The Casino virus, discovered about the same time last year as Michelangelo, may best embody this growing mean-spiritedness among virus writers. Triggered on the 15th of January, April, or August, Casino informs the victim that it has destroyed the file allocation table, which is used by DOS to track the location of files on a disk. But the virus has saved a copy of the file table in memory, and it offers "a last chance to restore your precious data" by playing a slot machine game. If you lose, it wipes out the file allocation table, making it impossible to access any of the files on the disk. A variant called Casino-B destroys the file table regardless of your luck.



"We're starting to see the angry young men come out now," says Robert Bales, executive director of the National Computer Security Association in Mechanicsburg, Pa. No one knows for sure who writes computer viruses or why, but the sophistication of today's viruses suggests the authors are talented young programmers with time on their hands and a taste for mischief. Viruses have originated in almost every country, including the United States, but many of the most common and dangerous ones come from Eastern Europe, particularly Bulgaria. In many of these countries are scores of well-trained computer programmers who have few opportunities to practice their art commercially. In addition, software piracy is rampant in many cases, allowing viruses to spread rapidly.

Anti-virus forces are fighting back with innovations of their own. Many anti-virus packages, including Symantec's Norton AntiVirus and Central Point's Anti-Virus, not only scan for known viruses, but also employ "sentry" programs that stay in memory and watch for suspicious activity, such as changes to files and boot areas, to try to catch unknown and stealth viruses at work. The programs usually intercept the virus and repair infected files.

A few anti-virus programs, including Certus International's Novi and Fifth Generation Systems' Untouchable, claim to be so good at monitoring a system for viral activity that no upgrades are necessary, as they often are for simple scanners. It's the sheer quantity of new viruses being developed all the time that necessitates these upgrades: The number of unique viruses soared from fewer than a dozen in 1986 to more than 1,000 by early 1992, and that number is expected to double by year's end, according to Patricia Hoffman, an independent virus researcher who maintains a database of all known computer viruses.

Scanning for virus signatures is still the backbone of nearly all anti-virus products; adapting the scanning techniques to snare encrypted and polymorphic viruses is not the impossible task it might seem. All encrypted viruses, even polymorphic ones, must leave a tiny portion of themselves —the "kernel" program that decodes the scrambled virus—unencrypted so the virus can still operate. At least one scanning program, a popular shareware program called Scan from McAfee Associates, already can detect

THE BULGARIAN CONNECTION

Many of the world's most common —and lethal—viruses come from a seemingly unlikely source: Bulgaria. Though hardly an economic or technology leader, Bulgaria is home to the notoriously destructive Dark Avenger viruses, the Mutating Engine scheme for encrypting viruses, the stealthy Int13 virus, and a number of other vexing strains.

Why Bulgaria? The principal reason is that Bulgaria has an army of well-trained computer wizards who have few options for putting their skills to good use, according to Vesselin Bontchev, director of the Laboratory of Computer Virology at the Bulgarian Academy of Science in Sofia. Under the direction of Communist party officials, says Bontchev, Bulgaria began a major effort to produce computers to supply the Soviet Union and circumvent Western embargoes on the delivery of high-tech goods. As part of that effort, software from the West was often illegally copied, spreading the few viruses in circulation. Young programmers gained little or no sense of professional ethics. Because the pay for such work is extremely low by Western standards, some programmers became embittered, according to Bontchev.

As in many countries, there is also very little legislation in Bulgaria regarding the misuse of computers in general and virus writing specifically. What's more, there is no money to fund an organized campaign against such abuses.

While many of the viruses written in Bulgaria are still confined to that country, the country's legion of experienced virus writers could create havoc. "In Bulgaria new viruses are written at an average rate of one per week," says Bontchev. As in the United States, viruses in Bulgaria spread mainly via floppy disks. Modems are relatively rare, but the few that are available are used to transmit viruses across Bulgarian borders and into Western bulletin-board systems. More than 50 Bulgarian viruses have spread beyond its borders. —*Wordservice International*

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the presence of viruses cloaked by the Dark Avenger Mutating Engine.

A number of creative hardware devices are helping stem the viral tide as well. ThunderByte PC Immunizer, from Glynn International of Brookline, Mass., is a $249 circuit board that plugs into an IBM-compatible PC and attaches via a cable to the system's hard-disk controller board. This connection physically prevents viruses from modifying program files or start-up areas of a hard disk. Virus Trap, a $295 board from JAS Technology of Warrenton, Va., offers similar protections. To reduce the risk of viruses entering a PC in the first place, Corporate Management Group of Austin, Texas, sells a series of floppy-disk-drive locks that the company characterizes as "chastity belts" for computers.

In their current form, however, anti-virus software and hardware products are flawed solutions, for no other reason than the fact that PC users must make the effort to buy and use them. Incorporating anti-virus technology into the operating system may be more effective. That would make the safeguards automatic and eventually extend them to almost everyone who uses a PC. Microsoft, which supplies the DOS operating system used by nearly all IBM-compatible PCs, says it is working on adding some file-system and boot-sector protections to a future version of DOS and to the next major release of its Windows graphical user interface.

But the operating system approach has its disadvantages. To accommodate anti-virus features, the operating system will probably use more system memory, and keeping anti-virus features up to date might mean more frequent upgrades of the operating system. Making virus protection the domain of an operating system like MS-DOS could also have the effect of painting a bull's-eye for virus writers. "Frankly, we're a little concerned it would look like we're throwing down the gauntlet," says Mack McCauley, manager of DOS and Windows development at Microsoft.

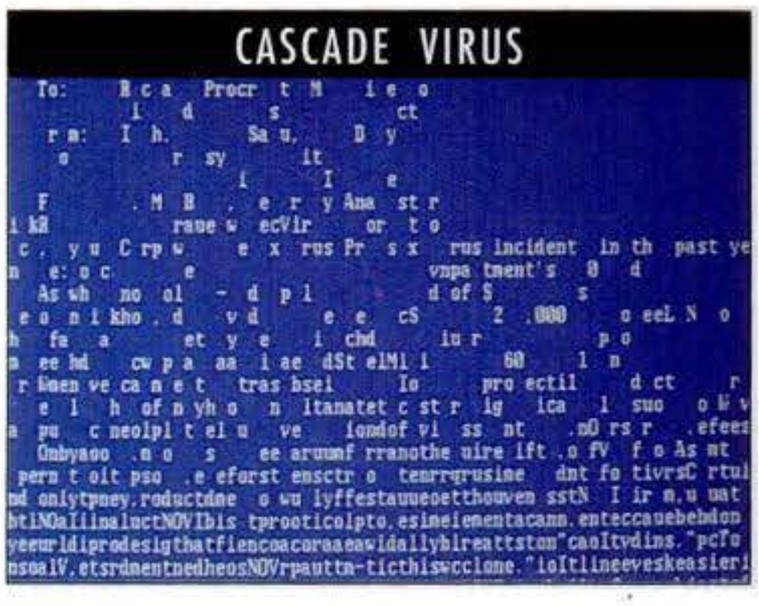
Nonetheless, beta versions of DOS 6.0, expected to be completed by early 1993, reportedly include Central Point's anti-virus software. Many PC vendors now include anti-virus software with their systems as well.

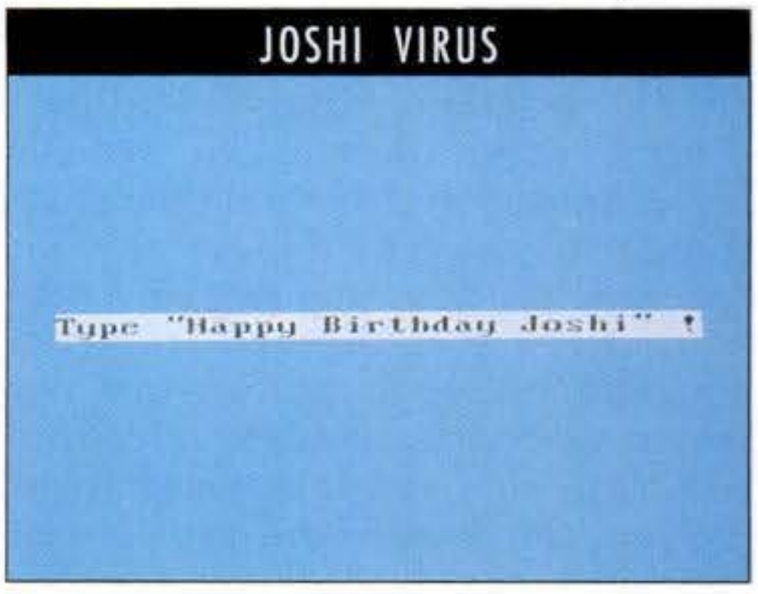
A more comprehensive and permanent answer to the virus dilemma may lie in redesigning PC hardware to close some of the openings that make a PC so vulnerable to rogue programs in the first place. Today's PCs allow any type of software—including viruses—to run unchecked, with unfettered access to critical disk and memory information. This hands-off approach is one element of the "open architecture" that has helped increase competition and cut the price of PCs. But it's also an open invitation to virus writers.

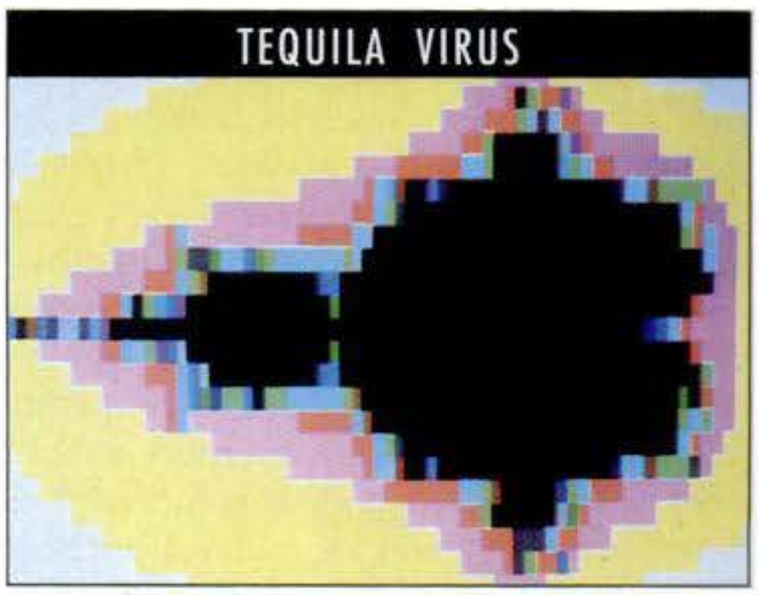
At George Washington University in Washington, D.C., Lance Hoffman, a professor of electrical engineering and computer science, and graduate student Paul Clark have proposed a new start-up procedure for PCs that would use solid-state memory cards instead of disks. This plan would eliminate the risk of boot-type viruses and make it easier to cleanse a computer that's been infected with file-type viruses.

Others have suggested that hardware makers design systems that would physically prevent viruses from writing to boot sectors or program files. Virus expert Richard Levin, author of *The Computer Virus Handbook* and an anti-virus program called Checkup, is promoting a built-in mechanism that would allow you to selectively protect boot sectors and program files by turning a keyed switch located on the front of the computer. (The key lock currently found on the faceplate of some PCs is simply a keyboard lock.) His system would still allow free access to data files. "PC users are entitled to security, and it should come with the computer," says Levin. "I think it's despicable that we're preying on people's misfortunes when we could stop this problem tomorrow if we really wanted to."

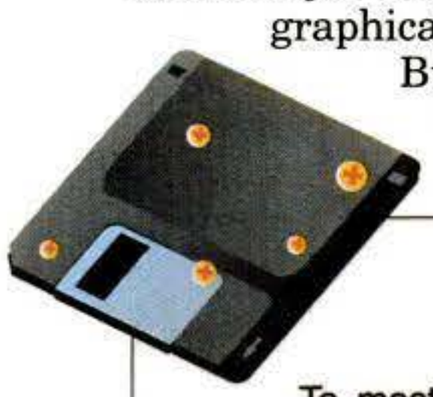
[*Continued on page 92*]







Viruses can have a variety of consequences, ranging from playful pranks to devastating destruction.



SPREADING "GOOD" VIRUSES

To most people, computer viruses are malicious programs that spread unchecked from machine to machine. But in computing as in medicine, viruses and the lessons they teach can be harnessed and put to benevolent uses.

The same properties that make viruses a threat to computers also make them attractive as problem-solvers. Without requiring the efforts of the users themselves, viruses can move quickly across a network of computers, perform a series of tasks with great efficiency, and adapt to changing conditions. Possible positive applications of virus technology include splitting up problems among many computers to get faster answers (called parallel or distributed processing), collecting and reconciling information from several databases, eliminating extraneous files, correcting system errors, and even updating software when new versions become available.

The notion of beneficial viruses is neither new nor merely theoretical. Frederick Cohen, a computer science professor who conducted groundbreaking experiments with viruses in the early 1980s, not only warned of their dangers but described their potential benefits as well. He demonstrated a useful data compression virus as part of his early research and has since developed data collection and network maintenance viruses for clients of his Pittsburgh consulting and research group, ASP Inc.

Cohen's maintenance virus, for example, moves throughout workstations on a network and deletes "garbage" files—temporary files created by other programs that are no longer needed. When there are no such files left to be "eaten," the viruses consume themselves. In general, these viruses would be subject to a kind of Darwinian process in which more successful viruses multiply.

The key to controlling such viruses, says Cohen, is to create a "viral computing environment," or software framework, that permits certain viruses to run on certain computers but does not allow them to spread to other systems. "Most people can only see the possibility of viruses getting out of hand," notes Cohen, "but the reality is they can be controlled." —*C. O.*

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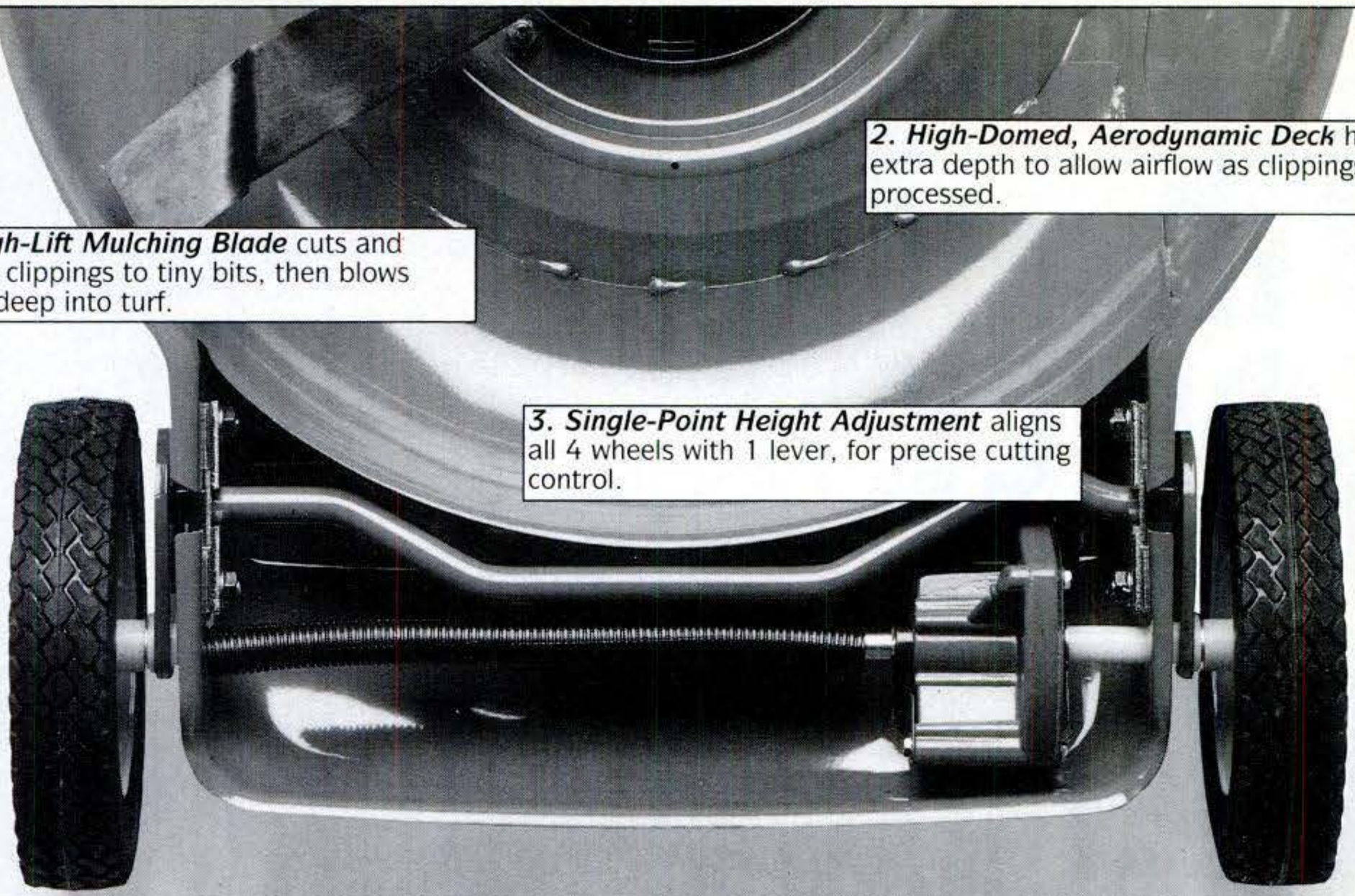
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THE HOUSE THAT JUNK BUILT

Steel framing made from old bridges, insulation from newspapers, and wood siding from mill scraps are part of this resource-conserving house.

BY SUZANNE KANTRA

Nailite plastic roofing from GE Plastics of Pittsfield, Mass., is made from old computer housings.
Insulation is made from shredded newspapers that are treated with fire retardant. On the attic and garage ceilings, a radiant-heat-barrier coating, LO/MIT-I from Solar Energy Corp. of Princeton, N.J., helps save energy.
FiberBond wallboard, made by Louisiana-Pacific Corp. of Portland, Ore., consists of gypsum, shredded newspapers, and perlite, which reduces panel weight while adding strength.
The frames of low-emissivity Fibron windows from Owens-Corning Fiberglas of Toledo, Ohio, feature an inner core of high-density fiberglass insulation, which is more efficient than regular fiberglass. The overall window insulative value is a solid R-3.39, which places it among the better-performing windows.
Seed and fertilizer are added to regenerated wood fiber, forming a green slurry called Spray Sod from Central Fiber of Wellsville, Kan. It's then sprayed on the soil in place of sod.
Weatherproof and impervious to UV light, recycled—and recyclable—Timbrex "lumber" from Mobil Chemical Co. of Norwalk, Conn. combines plastic grocery bags and sawdust.

Sixty-six percent of the steel used for the structural framing and doors comes from old cars, bridges, and scrapped industrial buildings.

Fiber ceilings from Armstrong World Industries of Lancaster, Pa., contain 22 percent recycled newspaper and up to 25 percent recovered mineral wool.

The ridge vent and soffit guards from Cobra Ventilation Co. of Wayne, N.J., are made with polyethylene terephthalate plastic that contains recycled plastic soda bottles.

Interflex-backed floors from Armstrong World Industries need no wood underlayment. Because they are glued only at the edges, they use 85 percent less adhesive than other vinyl floors.

Scrap wood chips and fiber constitute 85 percent of the molded exterior siding made by Abitibi-Price Corp. of Roaring River, N.C.

The cast-in-place concrete foundation by Lite-Form of Sioux City, Iowa, contains 20 percent recycled polystyrene insulation by Dow Chemical of Midland, Mich. An energy-saving frost-free shallow foundation for the garage was constructed using the same insulation.

Photovoltaic collectors from Solarex Corp. of Frederick, Md., power the outdoor lighting, security system, and indoor emergency lighting. A free-standing structure houses solar panels and contains the solar hot-water heater provided by American Energy Technologies of Green Cove Springs, Fla.

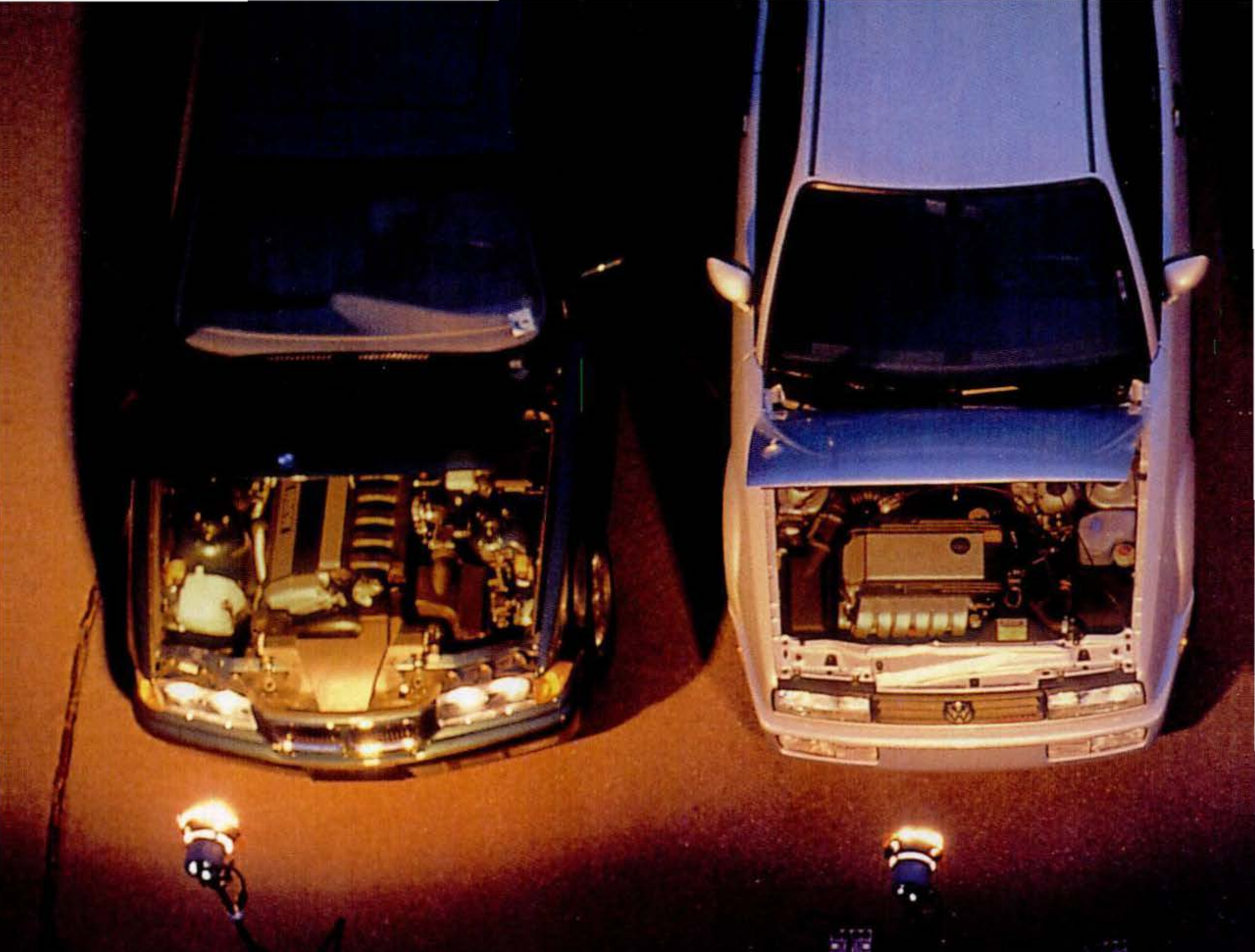
The copper pipes for plumbing are 70 percent recycled. Also, copper is the heat exchanger for the earth-coupled heat pump, which transfers heat directly to the ground instead of using another heat-transfer loop.

You would never know by looking at them, but the building materials in this seemingly ordinary new house already are in their second incarnation: They have been newspapers, old cars, sawdust, soft-drink bottles, polystyrene packing peanuts —even used computers.

But at the Resource Conservation House, conceived by the National Association of Home Builders Research Center, it is not only "garbage in." There is also almost no garbage out. Unlike most building sites, where nearly all waste is sent to a landfill, an estimated 90 percent of the scrap materials from this Upper Marlboro, Md., house were either recycled or reused on-site. Designed to conserve energy, the house uses solar power as well.

Building a resource-conserving house starts with careful planning to reduce construction waste. Architect

[Continued on page 90]



SIX

FOUR DIFFERENT SIX-CYLINDER ENGINE DESIGNS SET THE TONE FOR A QUARTET

Although there's more than one way to hang six cylinders on a crankshaft, lining them up single file is the time-honored and elegant engineering solution for dynamic balance and gas flow through the cylinder head. That's why the in-line design has been chosen for everything from a long line of velvety smooth Jaguars to an equally successful series of Chevy pickup trucks.

Today, BMW continues to expand on the basic merits of the in-line six-cylinder engine in its 3-Series cars, represented in this group by the 325is coupe. But most of today's top-performing sports coupes are powered by engines that deviate from the classic in-line design. The short-block V6, for example, solves the basic packaging problem when the engine is mounted transversely in a front-drive car like the new Ford Probe GT. Others are truly oddball efforts—such as the Subaru SVX's water-cooled flat-opposed layout, or the narrow-angle V6 in the Volkswagen Corrado SLC that has its cylinders squeezed so closely together they can share a single cylinder head.

With all of these answers, it's easy to forget the question. In fact, in today's world of homogenized engine design, it's

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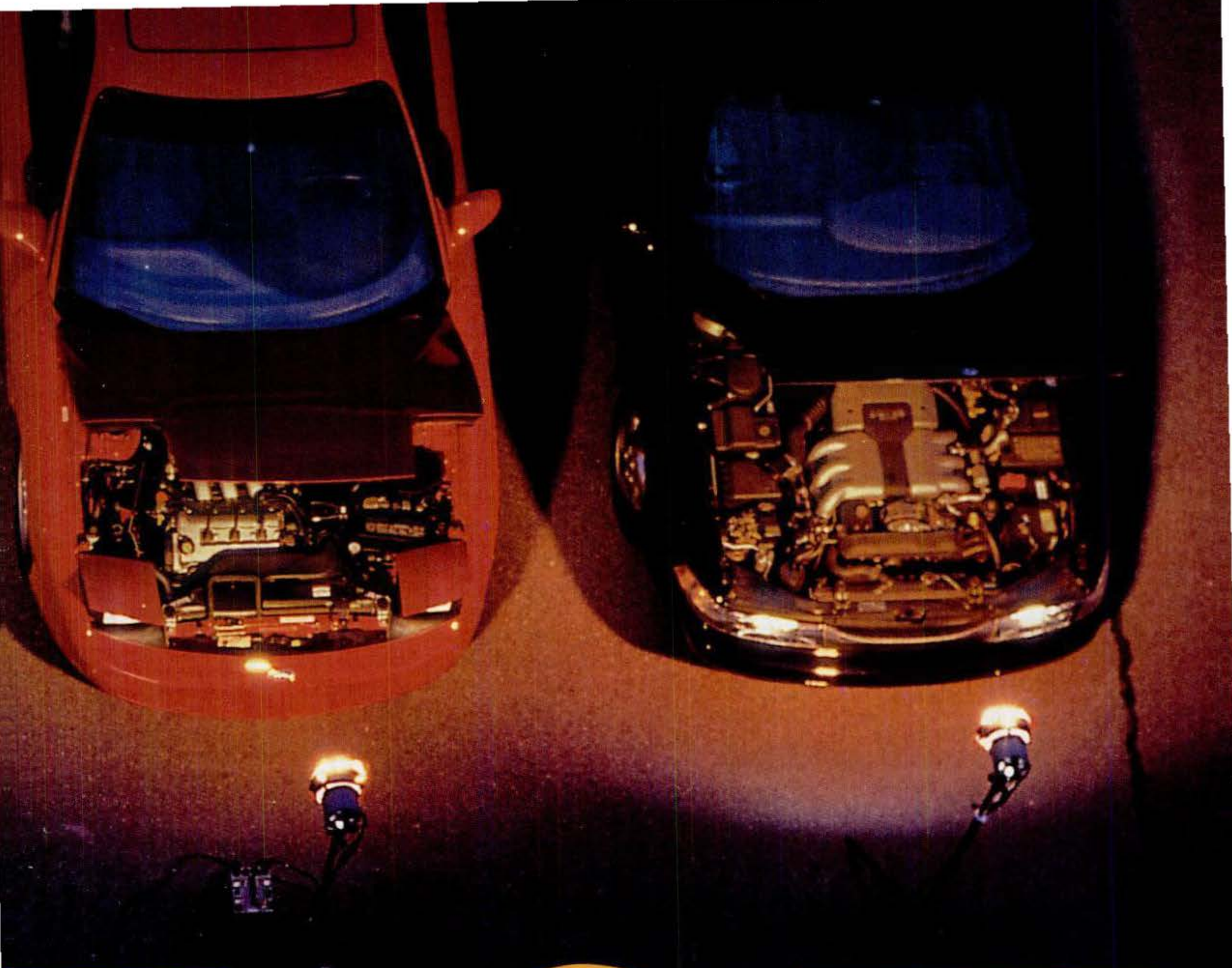

ES

BMW 325is

FORD PROBE

SUBARU SVX

VOLKSWAGEN CORRADO

OF NEW SPORTS COUPES. • BY DAN McCOSH

easy to dismiss the engine configuration as peripheral to the overall performance envelope. But the defining element of a sports car is what's under the hood, and the variations on the six-cylinder theme permeate the basic characters of the cars in this test group. When we gathered this quartet of sports coupes together, the urge to spend a few minutes peering under the hood was irresistible.

The architecture of Volkswagen's compact V6 is by far the most exotic of the group. With the cylinders set in two rows angled a mere 15 degrees apart in the cast-iron block, the basic approach is something like an in-line engine with staggered, overlapping cylinders. The main reason offered by VW for indulging in the extensive development time necessary to bring out the new engine is that the narrow block allows a wider crush zone in less space than either a 60- or 90-degree V6.

Because of its narrow angle and long stroke, the 15-degree V6 is also a relatively tall engine. The small (81-mm) bore restricts valve area, and the two-valves-per-cylinder head, actuated by two chain-driven overhead camshafts, is slightly asymmetrical; and designing an intake and exhaust manifold that works in such a confined space is diffi-

PHOTOGRAPHS BY JOHN B. CARNETT

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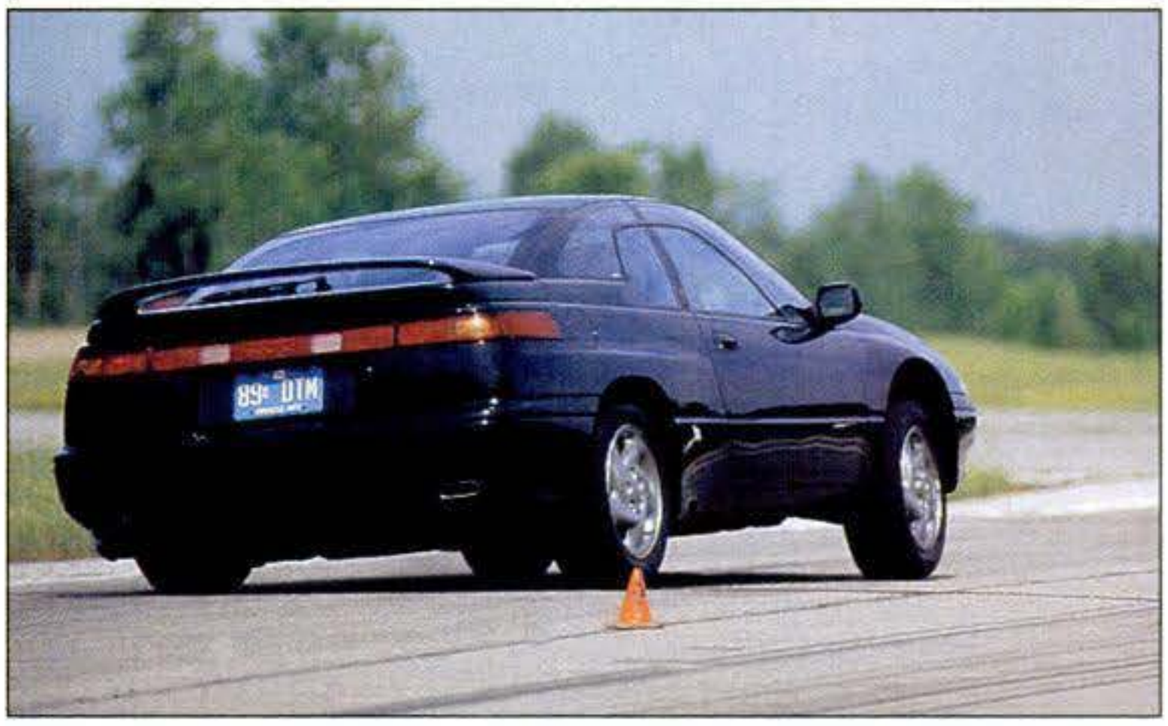


Taut suspensions provided flat cornering (from top): the VW Corrado, the Subaru SVX, the Ford Probe GT and the BMW 325is, with the Corrado sometimes showing air under the rear wheel.

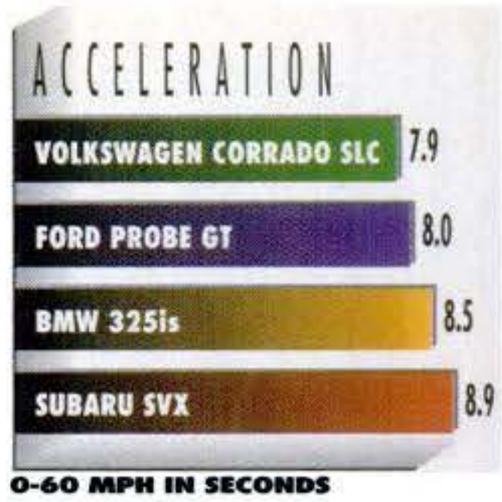
cult. It's noteworthy that the ignition system incorporates individual cylinder knock-sensing, which in effect sets a separate spark advance curve for each cylinder. This offsets minor variations in power from each cylinder.

The 2.8-liter engine in the Corrado produces 178 horsepower at 5,800 rpm. This is reasonable power-per-liter, and the claimed torque band, where 85 percent of maximum torque is available, is between 2,000 and 6,000 rpm—good in comparison to multivalve four-cylinder engines.

The tallish engine also would call for an unnaturally high hood line in most cars. But in the stubby yet streamlined Corrado, the engine tucks neatly under the sharply sloping hood line. The aggressive body shape sits on a relatively short and wide chassis with a revised suspension that increases damping and slightly lowers the roll center. Although the Corrado is decidedly nose-heavy, with some 64 percent of its weight on the front wheels, it's actually not much worse than the Ford Probe.

Rather than the understeer tendency you would expect with so much weight on the front wheels, the Corrado is neutral under most conditions, with a tendency to tuck in its nose to the inside of the line when the throttle is lifted. The Corrado is smoother and more predictable overall than its supercharged four-cylinder-powered predecessor, and the new V6 transforms a formerly rough-edged sports coupe into a free-spirited, free-revving driving experience.

The compact interior, with highly supportive but smallish seats and a straightforward instrument panel, marks the Corrado as a relatively serious and uncompromising driving machine. Less serious is the speed-sensitive spoiler that pops up at about 45 mph—a speed too slow to have any serious aerodynamic effect—effectively blocking rear vision.



Like the Corrado, the Ford Probe, the other front-drive car in this group, has evolved into a sophisticated driving machine now in its second generation. The Probe, along with the Mazda MX-6 (see Mazda MX-6: Probe's Twin Under the Skin), is built in Mazda's plant in Flat Rock, Mich.

When it was launched in 1988, the original Probe raised the anxiety levels of V8-powered-Mustang enthusiasts as rumors abounded that it would eventually replace Ford's long-popular pony car. Ford had, in fact, contemplated such a move, but Mustang loyalty prevailed. (An all-new Mustang is due in 1994.) Happily, the Probe quickly discovered its own following in the crowded sports coupe field.

The original Probe was a dramatically styled commercialization of a Ford of Europe concept car that originated the name. Ford's styling tended to overshadow Mazda's original

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MAZDA MX-6: PROBE'S TWIN UNDER THE SKIN

The Mazda MX-6, along with its Ford Probe sibling, is built in a Mazda plant in Flat Rock, Mich.—just a stone's throw from Ford's historic Rouge complex on the edge of Detroit's city limits. It's been an unusually successful joint venture, compared with the Tweedledum-and-Tweedledee packages that seem to result when American and Japanese companies join forces to manufacture two models that end up as mirror images of each other.

Mazda provides the basic component engineering and manufacturing expertise, while each company's designers and engineers have developed exterior shapes and fine-tuned their respective chassis to make two distinctly different vehicles. Compared with the highly sculpted Probe, the MX-6 is more basic, less contemporary. Ford's version is a liftback, while Mazda offers a simple coupe with a small-ish trunk. The additional weight of the structure needed at the rear for the liftback gives the MX-6 a significant weight advantage. The result shows up in acceleration. The MX-6's 8.1-second 0-to-60-mph run beats the Probe's by 1.6 seconds.

The liftback also affects weight distribution, making the MX-6 appear nose-heavy on paper with 65 percent of its weight on the front wheels. The lighter weight and quicker acceleration of the MX-6 leads to a certain irony, however, as the noticeably slower Probe is tuned more aggressively than the MX-6, with quicker steering and stiffer suspension. The MX-6 has speed-sensitive power steering, while the Probe uses a fixed-ratio steering box. On balance, despite the edge in acceleration, the MX-6 remains the softer, less aggressive car likely to be spurned in favor of the Ford version by the driving enthusiast.—*D. M.*

MX-6, built on a shared chassis. Both cars relied on a turbocharged version of Ford's four-cylinder engine that was powerful, but prone to torque-steer to the point that it caused some handling problems.

The V6 option transforms the Probe, which has been restyled and retuned for 1993. The aluminum block 24-valve V6 delivers 164 hp and 156 pound-feet of torque, while adding smoothness and flexibility that was lacking in the previous-generation turbo. The new Probe body is smoother, more sculpted in shape, and the interior is far more contoured than the original. Because the Probe is a liftback, the 100 pounds of additional weight affect acceleration times. But this weight gain doesn't seem to influence performance at the track, where handling was crisp and nearly faultless, with any torque-steer problems happily cured. The Probe is clearly a car designed for the hard-core enthusiast.

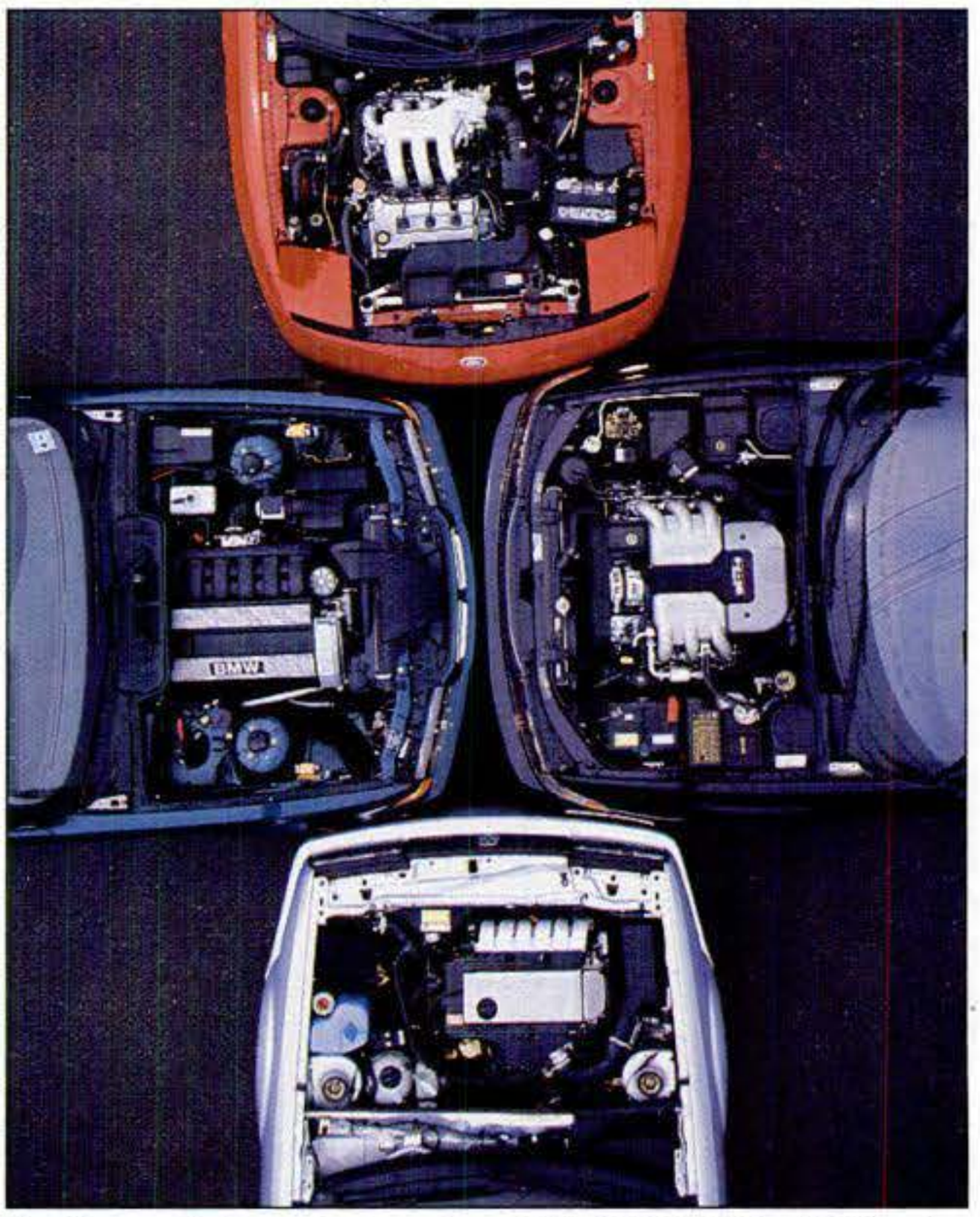
That same enthusiast is likely to be baffled when first encountering the Subaru. The SVX's expansive side windows wrap up into the roofline and are bisected by a short, movable panel that is little more than an armhole in a glass bubble. It's the kind of styling that usually starts and stops with exotic concept cars displayed at auto shows, but Subaru chose to put it on the street.

It's only partially successful, however, in trading utility for drama. After a week or so the novelty wears off, the motorized seat belts catch your head one too many times in their huge arcs, and the black window frames that are chronically in your peripheral vision are simply irritating.

The SVX drivetrain is likewise quixotic. A powerful 3.3-liter, 230-hp flat-opposed six is reminiscent of a poor man's water-cooled Porsche. The power is gained with complex 24-valve heads and multipoint sequential fuel injection. The engine is located up front, where it sends power through a four-speed automatic transmission into one of the more sophisticated four-wheel-drive systems on the market today. This system uses a hydraulically actuated wet multiplate clutch to proportion torque across the center differential, which distributes power front to rear. With appropriate sensors and a limited-slip rear axle, this setup should theoretically provide proper power balance at all four wheels.

It works most of the time: Until it is close to its limits, the SVX is a joy to drive, giving a sense of being planted on the highway. But pushed hard, the SVX alternates between a tendency to plow on turn-in and tail-happiness when the throttle is lifted, reacting pretty much like a mildly ill-mannered front-wheel-drive car. Part of this is because the four-wheel-drive system responds mainly to excessive wheel slip, which means it does not truly engage until tire grip is already lost. Another reason is the SVX's 59:41 front-rear weight distribution, which is more typical of a front-wheel-drive car. The bottom line is that the SVX is oriented more for highway cruising, particularly in inclement weather, than for hard-core handling.

In contrast, pure handling finesse is what BMW is all about. Exactly what makes the new BMW 325is work as well as it does is sometimes difficult to pin down from a specifications sheet. From its frumpy but familiar, and not particularly aerodynamic, styling to the mechanical



The fore-and-aft engine locations of the BMW 325is (left) and Subaru SVX (right) take up more space under the hood than the transverse-mounted engines in the Corrado (bottom) and the Probe (above).

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anachronism of the in-line six-cylinder engine, this sports sedan seems to make a mockery of the notion of unrequited technical progress.

The double-overhead-cam, 24-valve in-line six is a monument to straightforward design, assembling all of today's high-tech basics, including electronic fuel-injection, twin overhead cams, and distributorless ignition in a package that clearly dominates this group in specific power output: The 2.5-liter engine delivers 189 hp at 5,900 rpm, and 181 pound-feet of torque. With a curb weight slightly more than 3,000 pounds, its acceleration does not match the horsepower superiority, but it's quick enough.

BMW was one of the first, but not the last, to introduce an all-plastic intake manifold. The advantages are lighter weight, less heat transfer through its walls, and an ultrasmooth interior. In an intriguing turnabout from conventional plastic molding techniques, the manifold is molded with a low-melting-point metal core that is later melted out from the finished high-temperature plastic piece.

The various routes to power do not necessarily finish in order of efficiency. Ultimately, acceleration is limited by all-up weight, and the 3,557-pound Subaru SVX is slowest to 60 mph despite its power edge. The flat six is also not particularly smooth. The BMW 325is is only slightly quicker, again because of weight, despite having the highest specific output and being second in horsepower rating. (The BMW also was loudest on the sound meter.) The new Mazda V6 in the Probe is smoothest and quiet almost to a fault, and it edges out the Corrado in acceleration when installed in the lighter MX-6. The six-cylinder power plants thus set the tone of these designs, but it is the all-around combination of chassis, handling, styling, and power that completes the whole.

The 325's handling is aggressive and predictable, al-

[Continued on page 92]

THE PROBE IS STILL HOT

I had trouble warming up to the Subaru SVX. Acceleration is respectable given the weight of the four-wheel-drive system and automatic transmission this car has to drag around, but the SVX never felt quick or agile to me. Ponderous and sluggish describe the SVX more accurately. It should be clear from this test that four-wheel drive is no panacea for dry handling. Also, the flat-six is not particularly smooth, and in the SVX it's located very high in the chassis, well above the axle centerline. But where four-wheel drive is a significant asset for winter driving, the SVX makes some sense.

The new engine does wonders for the Corrado, now that it feels quick and agile the way a nifty sports coupe should. Three things annoyed me: no air bag, the dumb "active" rear spoiler, and a shifter that had to be pressed down to get out of reverse. The engine, however, is a thing of beauty: quiet, powerful, and eager to rev.

The BMW is a nice car, as are most BMWs. The engine is exceptionally smooth, and it makes delicious sounds while being exercised. The backseat is decently roomy and useful for transporting real people. The one problem I have with this car is the price/acceleration ratio. For $30,000, it should be quicker. In fact, it should have a three-liter engine instead of the measly 2.5-liter.

The design of the Probe grows on me by the day. It is easily the hottest looking affordable sports coupe of the moment. The mechanical improvements that come with the redesign are also impressive. Good riddance to the old turbo four and welcome to a lovely little V6 in its place.

Mazda's intention with the MX-6 was classic coupe styling that will last for more than the usual two years. With that in mind, I'd say that it certainly doesn't look as good as the Probe today, and my guess is that I'll feel the same way two years from now.—*Don Sherman*

POPULAR SCIENCE TEST RESULTS

	BMW 325is	Ford Probe GT	Subaru SVX	Volkswagen Corrado SLC
ACCELERATION and HANDLING				
0-30 mph (sec.)	2.9	3.3	2.8	3.0
0-60 mph (sec.)	7.9	8.9	8.0	8.5
30-50 mph (sec.)	8.7	5.4	9.3	10.4
50-70 mph (sec.)	9.0	5.3	9.7	10.0
Double-lane change (mph)	59.4	55.2	59.8	57.8
Slalom (mph)	47.4	45.7	47.5	46.0
Road-holding (g)	0.80	0.84	0.84	0.84
BRAKING				
Cold (ft.)	136	124	140	131
Warm (ft.)	132	133	130	133
Hot (ft.)	135	135	131	133
INTERIOR NOISE				
Idle (dB)	51	41	48	51
60 mph (dB)	68	66	66	67
0-60 mph (dB)	76	78	74	82
SPECIFICATIONS				
Engine	2.8L V6	3.3L flat 6	2.5L V6	2.5L I6
Valve train	SOHC 2 valves/cyl.	DOHC 4 valves/cyl.	DOHC 4 valves/cyl.	DOHC 4 valves/cyl.
Power (hp@rpm)	178@5,800	230@5,400	164@6,000	189@5,900
Torque (lb.-ft.@rpm)	177@4,200	224@4,400	156@4,000	181@4,700
Compression ratio	10.0:1	10.0:1	9.2:1	10.1:1
Transmission	5-speed automatic	4-speed automatic	5-speed automatic	5-speed automatic
Final drive ratio	3.65:1	3.54:1	4.39:1	3.15:1
CHASSIS				
Front suspension	MacPherson strut, coil springs, anti-roll bar	MacPherson strut, coil springs, anti-roll bar	MacPherson strut, coil springs, anti-roll bar	MacPherson strut, coil springs, anti-roll bar
Rear suspension	Independent, two trailing arms integral with a twist beam-coil springs, anti-roll bar	Independent, strut type located by one trailing and two lateral links, coil springs, anti-roll bar	Independent, strut located by one trailing and two lateral links, anti-roll bar	Independent, multi-link, coil springs, anti-roll bar
Steering gear	Rack-and-pinion; power assist	Rack-and-pinion; power assist	Rack-and-pinion; power assist	Rack-and-pinion; power assist
Turning circle (ft.)	34.4	35.4	35.4	34.1
Brakes (front, rear)	ABS; vented disc, disc; power assist	ABS; vented disc, drum; power assist	ABS; vented disc, disc; power assist	ABS; vented disc, disc; power assist
EPA MILEAGE				
City	18	17	21	18
Highway	25	25	26	26
DIMENSIONS				
Wheelbase (in.)	97.3	102.8	102.9	106.3
Length (in.)	159.4	182.1	178.9	174.5
Width (in.)	65.9	69.7	69.8	67.3
Height (in.)	51.9	51.2	51.8	53.8
Curb weight (lbs.)	2,789	3,557	2,874	3,044
Distribution % (front:rear)	64:36	59:41	63:37	50:50
Fuel tank (gal.)	18.5	18.5	15.4	17.2
Interior volume (cu. ft.)	79.9	84.5	79.9	81.4
Trunk volume (cu. ft.)	15.3	8.2	11.0	14.3
PRICES, PARTS, AND LABOR				
Base price	$22,170	$26,250	$15,174	$29,100
Price as tested	$23,945	$29,600	$19,811	$30,805
Major options (over $100)	Antilock brakes $835; leather upholstery $770; metallic paint $170	Leather upholstery $3,000; rear spoiler $350	Preferred equipment package $3,761; sunroof $646; AM-FM stereo with CD player $501; power driver's seat $305; anti-theft system $200; graphic equalizer $139	Limited-slip differential $510; metallic paint $435; trip computer $410; heated front seats $350
REPAIR: PARTS/LABOR*				
Front brake pads	$ 93/73	$ 92/22	$ 52/40	$ 97/46
Front shock/insert	176/50	238/96	155/40	324/80
Alternator	595/98	569/17	518/30	372/46
Water pump	119/123	104/135	94/110	84/103
Windshield	393/115	900/87	545/90	425/34
Headlamp assembly	252/38	411/22	79/20	262/34

*Labor costs reflect manufacturer's flat-rate time allowance multiplied by typical dealership labor rates per hour.

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CRACKING THE CODE

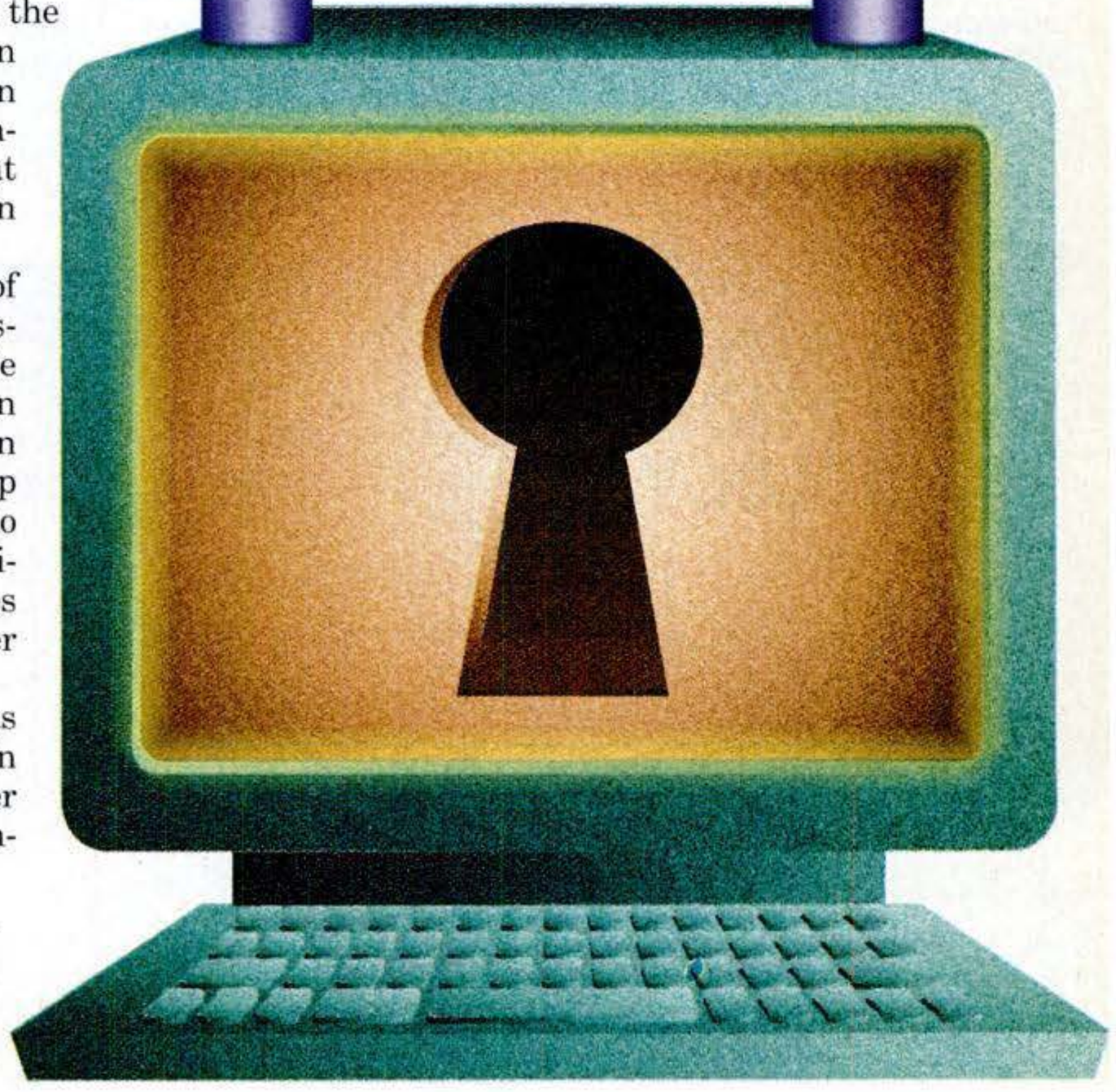
A mathematician claims he has discovered a weakness in the encryption standard used to encode bank transactions, faxes, and other electronic messages.

BY MARK D. UEHLING

Last April, detectives in San Diego stumbled upon a national network of about 1,000 computer hackers who had breached more than the conventional password-related defenses of banks and credit card companies. In the months after the first arrests in California, police caught ringleaders in New York, Florida, Arizona, Pennsylvania, Washington, and Ohio. Among other financial data, the hackers had illegally divined the personal identification numbers used in automated teller machines. These numbers are encrypted with a special federally approved scrambling formula intended to protect the customers of every bank. But the hackers were able to thwart that encryption. They even used other scrambling techniques to hide their own records from police. "The hackers have their own encryption system that is probably better than any at IBM," says Dennis Sadler, the San Diego detective in charge of the case.

Banking identification numbers depend on the sort of scrambling code used to generate the gibberish displayed on Robert Redford's computer screen in the movie *Sneakers*. This code can garble any form of information —words or numbers—stored as computer data. It can prevent eavesdropping on telephone conversations, keep facsimiles out of the wrong hands, and safeguard radio broadcasts. Crop reports at the U.S. Department of Agriculture are encrypted with it. So are Nintendo cartridges and money (most funds move from one bank to another via computers, not armored cars).

The original name of the devilishly versatile code was Lucifer. At IBM, where the formula was devised early in the 1970s, executives despaired of profiting from Lucifer and released it to the public domain. The U.S. govern-



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ment, which has long collaborated with IBM, tinkered with the code and renamed it the Data Encryption Standard, or DES. Aware of the many illicit uses to which sensitive government information could be put, Congress mandated DES encoding for federal computer files. It was adopted as a national standard in 1977. With government approval, DES gained wide public use first in banking and more recently in personal computers and facsimile machines.

Fortunately, considering the stakes, most cryptographers have complete faith in the code, believing it will never be cracked. To the credit of IBM and its allies in the intelligence agencies, a generation of mathematicians have spent their careers trying to break DES without success. While other codes fell to one mathematical attack or another, DES remained invulnerable, invincible, uncrackable.

Now, however, that impressive record seems destined to end. The speed of integrated circuits has grown at a fantastic rate, and it is not impossible to envision a day when supercomputers will be powerful enough to search all possible passwords for the key to a DES message. "All cryptography has a natural life span, and advances in technology will reduce the security provided by DES in the future," concedes Michael S. Conn, chief of information policy at the National Security Agency (NSA), a Pentagon division devoted to electronic espionage.

The federal government recognized the vulnerabilities of DES in 1988, when the NSA decertified DES for classified purposes within the government. For the customarily silent espionage establishment, that was a shotgun blast alerting the computer industry that DES was no longer wholly reliable. By then, however, American banks had adopted DES so completely that some form of federal approval was demanded by the business community. The Commerce Department obliged, reapproving DES. However, Commerce's reputation for world-class code-making is weaker than that of the NSA, which has more cryptographic brain power than any university in the world.

One possible reason why the NSA sounded the alarm about DES is because the code is so well known. As Conn of the NSA explains: "Government use of DES equipment has spread to applications making [DES] increasingly attractive as a potential target for adversaries of the U.S. government." Indeed, unlike the classified cryptography used for top-secret military plans and the Oval Office telephone, DES is an open book. Its workings have been described in official U.S. government publications and countless technical articles.

In the basic DES procedure, a letter or document is converted into numbers. These numbers are then replaced and reordered using numbers selected from a key—a password-like number chosen by the person encrypting the message. The substitution and reordering occur gradually so that the message and the key are thoroughly mixed. The resulting number is then scrambled again and again, for a total of 16 rounds of manipulation. By the end, a phrase such as "Cancel Plan B!" becomes 3102 5896 4807 1192 5046 1891 0288. The numbers can only be converted back into "Cancel Plan B!" if they are put through the same scrambling operations in reverse order, using the same key.

A DES key is 56 binary digits long. In the world of computers, each digit can be either a one or a zero, so the number of possible keys that can be used is two raised to the 56th power. That works out to 72,057,594,037,927,936 different ways to encode a message with DES.

Cryptographers haggle over how much time is needed to plow through these 72 quadrillion passwords. Some say a month; others believe it could be done in a few hours on a supercomputer dedicated to the task. "There must be thousands of computers that could succeed with a brute force approach," muses David Stang, research director of the National Computer Security Association. "A desktop computer you can buy for $20,000—maybe it sits on the floor by your desk—is certainly as powerful as anything the National Security Agency owned a decade ago when the standard was first discussed. And a desktop computer could succeed in some cases." Thanks to faster silicon chips, parallel processing, and ever-better supercomputers ["The Teraflops Race," March '92], even those with faith in DES agree that someday soon DES keys will be searched and tested with ease.

What's more, 16 rounds of substituting and reordering may not be enough to protect a message from prying eyes. In 1974, when DES was first published in the Federal Register, 16 rounds seemed more than sufficient. But as many cryptographers have shown, sometimes informally at conferences, they can track a message through three-quarters of those rounds before getting lost in the maze of numbers. "There are theories that you can break a 12-round data encryption scheme without a tremendous amount of trouble," says Gary S. Morris, a Pentagon consultant on information security.

DECIPHERING THE RSA ENCRYPTION TECHNOLOGY

The RSA Public Key Cryptosystem encodes text using a matched pair of keys—a public key and a private key. That solves the problem of having to share a single key, which could be intercepted as it is passed between users.

Like all computer-based encryption technologies, RSA first turns plain text into a series of numbers. In this example, each letter is converted to a two-digit number: A=01, B=02, and so on. TEXT becomes 20 05 24 20.

Numbers representing the text are then raised to a huge exponential power and divided by the product of two prime numbers. In this example, the product is 183,457. But in actuality, the number used would have at least 150 digits.

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It was against this backdrop that a gifted but self-promoting mathematician named Adi Shamir stepped forward in the fall of 1991 to announce he had discovered a "weakness" in DES. Shamir, a professor at Israel's Weizmann Institute of Science, distributed his tantalizing comments over an international computer network. In the close-knit world of cryptography, the announcement was big news; today the essence of Shamir's finding is about as widely known as DES itself.

Collaborating with graduate student Eli Biham, Shamir developed a technique called "differential cryptanalysis." The technique currently has little practical application in breaking DES, but it outlines a method for discovering a DES key without trying all of the 72 quadrillion possibilities. In essence, Shamir claims that if he is given enough messages encrypted with the same DES key, he can detect a pattern that will allow him to decipher other messages.

"Computers are hundreds or thousands of times more powerful than they were when DES was first developed," says Nathan Myhrvold, vice president for advanced technology at Microsoft Corp. "Shamir's work makes it potentially feasible to break DES without brute force. DES doesn't afford the same measure of security [as it once did]."

For now, though, DES appears to be safe from Shamir's attack. Although his technique is a shortcut that makes it unnecessary to test 72 quadrillion passwords, there's a hitch: To identify a DES key, Shamir must first obtain several trillion messages encrypted with that key, as well as the original texts. That requirement makes it exceedingly difficult for him to crack the code.

A top IBM research scientist, Don Coppersmith, who worked on DES in its early days says the company anticipated Shamir's analysis more than 15 years ago, in the mid-1970s. According to Coppersmith, the DES formula is strong enough to withstand the attack. Shamir's technique won't work, Coppersmith maintains, unless a code-cracker can either persuade his enemy to encrypt an unimaginable quantity of data or commandeer his enemy's computer. If Joe Q. Hacker wanted to identify a DES key used by the First National Bank in Chicago, he would have to take control of the bank's computers for months or years.

On a theoretical level, Coppersmith says, the IBM team anticipated a hacker who might try to break DES by analyzing differences in the enciphered versions of two similar messages. To do so, a hacker would need to detect a faint

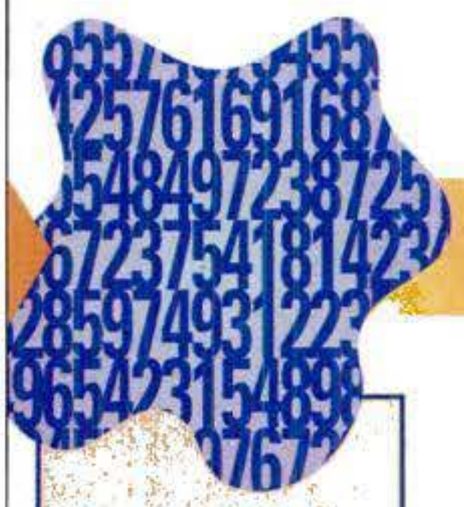
A DE FACTO STANDARD?

Despite the opposition of the U.S. government, many of the largest computer hardware and software companies have already adopted the RSA Public Key Cryptosystem. The licensees include Apple Computer, AT&T, Digital Equipment Corp., Lotus Development Corp., Microsoft Corp., Motorola, Northern Telecom, Novell, Sun Microsystems, and even IBM—inventor of the encryption method that is currently the official U.S. standard.

The RSA technology is already widely used in the United States. The National Science Foundation, NASA, the Central Intelligence Agency, the Pentagon, and the State Department are RSA customers. Banks using the technology include Chase Manhattan and Chemical Bank. Boeing, Du Pont, Exxon, Hughes Aircraft, Raytheon, Rockwell International, Texas Instruments, and Whirlpool are among RSA's corporate customers.

The technology is also widely used in Europe and Australia, and has been adopted by several international standards bodies. It is the official standard of the Internet network.

Microsoft licensed the technology in June 1991 for use in its Windows NT computer operating system, and Apple plans to include RSA encryption in its soon-to-be-released Open Collaboration Environment operating system for Macintosh computers. That could place astonishing cryptographic power in the hands of individuals, thwarting even the most sophisticated mathematical attacks. Encryption-equipped computers could also become popular with businesses concerned about security in a world in which computer thieves ranging from lone hackers to giant companies or even foreign governments get smarter and bolder. Nathan Myhrvold of Microsoft imagines security programs becoming a fact of life. "There'll be as many uses for this as you find for locks in your house today," he predicts.—*M. D. U.*



The remainder of the fraction is the encrypted bit of information that is stored in the computer or transmitted over phone lines. By this time, it is hopelessly garbled. Only someone with the private key can read it.

The private key contains the two prime numbers—normally much larger than the ones shown here— that were multiplied together to create the public key. Even if you know the public key, it's extremely difficult to figure out what numbers are in the private key.

The private key and public key have inverse functions: What one does, the other can undo. Here, the private key turns the garbled numbers back into the numerically encoded version of the original text.

The numbers are converted back to text, revealing the decrypted document or message. The RSA technology is sometimes used to encrypt a numerical key. That key, in turn, is used to encrypt text by a speedier but less secure method.

TOM WHITE

HIGH-TECH PRIVACY

You're a businesswoman, and your laptop is filled with your company's financial secrets—not to mention your own tax return. Is all that juicy information safe? No. Computer security experts say anyone smart enough to steal your computer will be smart enough to get your secrets out in good condition.

But there are many new ways to protect yourself. To ensure that a pilfered computer is useless, Secura Technologies of Laguna Niguel, Calif., offers a small token that attaches to your key chain and resembles a watch battery. When you touch the token to a receptacle on the keyboard, a silicon chip delivers an unalterable number that allows the bearer of the token to use the computer. Without the token, the information is useless: It has been encrypted.

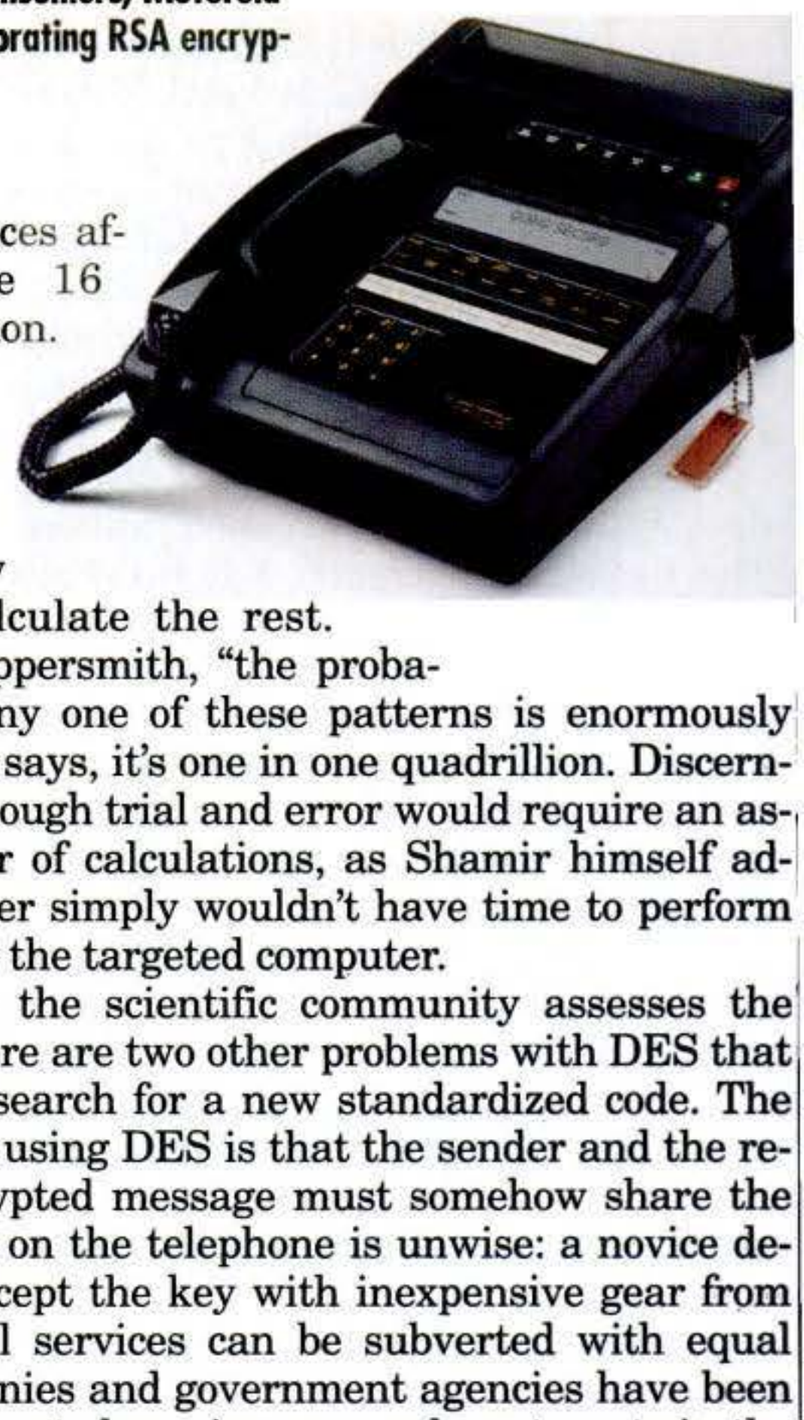
For those who would rather not install new chips, publishers offer a variety of DES-based software with names like Watchdog, Total Security, and PCTools. Such programs can encrypt letters, spreadsheets, and messages so that no one who gains access to your computer will have any idea what's inside. But be forewarned: Take care in choosing your password, and change it often. Exercise common sense in securing the area near your computer. "There are certainly ways of pulling information out of computers even when it's encrypted," says Cheryl Helsing of Deloitte & Touche, a specialist in information security. "If you're talking about a software implementation of DES, that's not bulletproof."

To encrypt facsimiles, Möbius Encryption Technologies in Ontario sells a DES-based box that attaches to the fax machine. The only glitch is that each recipient of an encrypted fax must have an identical box to decrypt the transmission. Möbius also sells computer circuit boards that encrypt faxes; its elite government-approved customers include the Bank of England and Lloyd's of London.

Finally, for those interested in the new generation of scrambling, RSA Data Security in Redwood City, Calif., markets its formula through some of the major hardware and software companies—and on its own. All Macintosh computers, for example, will soon have RSA built in at the factory.

One of the most intriguing possibilities may come from Motorola. The electronics company has paid for the right to use RSA codes in digital telephones. The company declines to say exactly what it will do with RSA's technology, but it could effectively put an end to the wiretap.—*M. D. U.*

For security-conscious consumers, Motorola offers telephones incorporating RSA encryption technology.



pattern of differences after each of the 16 rounds of encryption. By finding that pattern, in theory, a hacker might be able to identify part of the DES key —and quickly calculate the rest. However, says Coppersmith, "the probability of finding any one of these patterns is enormously small." At best, he says, it's one in one quadrillion. Discerning the pattern through trial and error would require an astronomical number of calculations, as Shamir himself admits. A code-cracker simply wouldn't have time to perform the calculations on the targeted computer.

No matter how the scientific community assesses the Shamir attack, there are two other problems with DES that have spurred the search for a new standardized code. The biggest obstacle to using DES is that the sender and the recipient of an encrypted message must somehow share the key. Mentioning it on the telephone is unwise: a novice detective could intercept the key with inexpensive gear from Radio Shack. Mail services can be subverted with equal ease. Large companies and government agencies have been reduced to using trusted couriers; some departments in the U.S. and Canadian governments spend millions of dollars a year using such messengers. However, couriers are out of the question for a sender and a recipient who have never met: The recipient has no way of ascertaining whether the DES key and the message are genuine.

Worse, many cryptographers in academia and industry have long suspected that the government can already break the widely used DES code. Its motive: to intercept the communications of foreign governments, terrorists, or the Mafia. The government has long denied this ability exists, as does IBM. But the NSA's expertise in cryptography is so esteemed, so revered, that many cryptographers assume the government can devote a supercomputer or a battalion of analysts to cracking an important DES key.

"Undoubtedly the U.S. government knows how to break DES," says Harold J. Hyland, editor emeritus of the journal *Computer Security* and a former intelligence officer. "The people capable of breaking it could never publish it. They work for the government or in academia. If you did find a way to break it, you'd find it very hard to get funding." Many in the field share Hyland's view and cite the government's role in the birth of DES—when, at the NSA's request, IBM shortened the original key. That made DES easier to break.

The skepticism over DES intensified when the Commerce Department's National Institute of Standards and Technology (NIST), guided by the NSA, proposed a new standard in 1991—a so-called digital signature—for verifying and authenticating any electronic document. Shortly after the government proposed its method, a pair of mathematicians at Bellcore, the research arm of the regional Bell telephone companies, announced several shortcomings. The bottom line: Under the new proposal, the government might be able to forge any signature or read any document.

"Their proposal had a number of things wrong with it," says Bellcore mathematician Stuart Haber. Speaking of a hypothetical bureaucrat, he adds: "If he does a very simple bit

[*Continued on page 84*]

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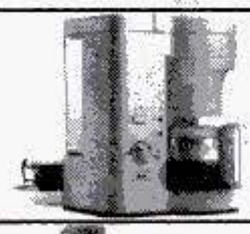

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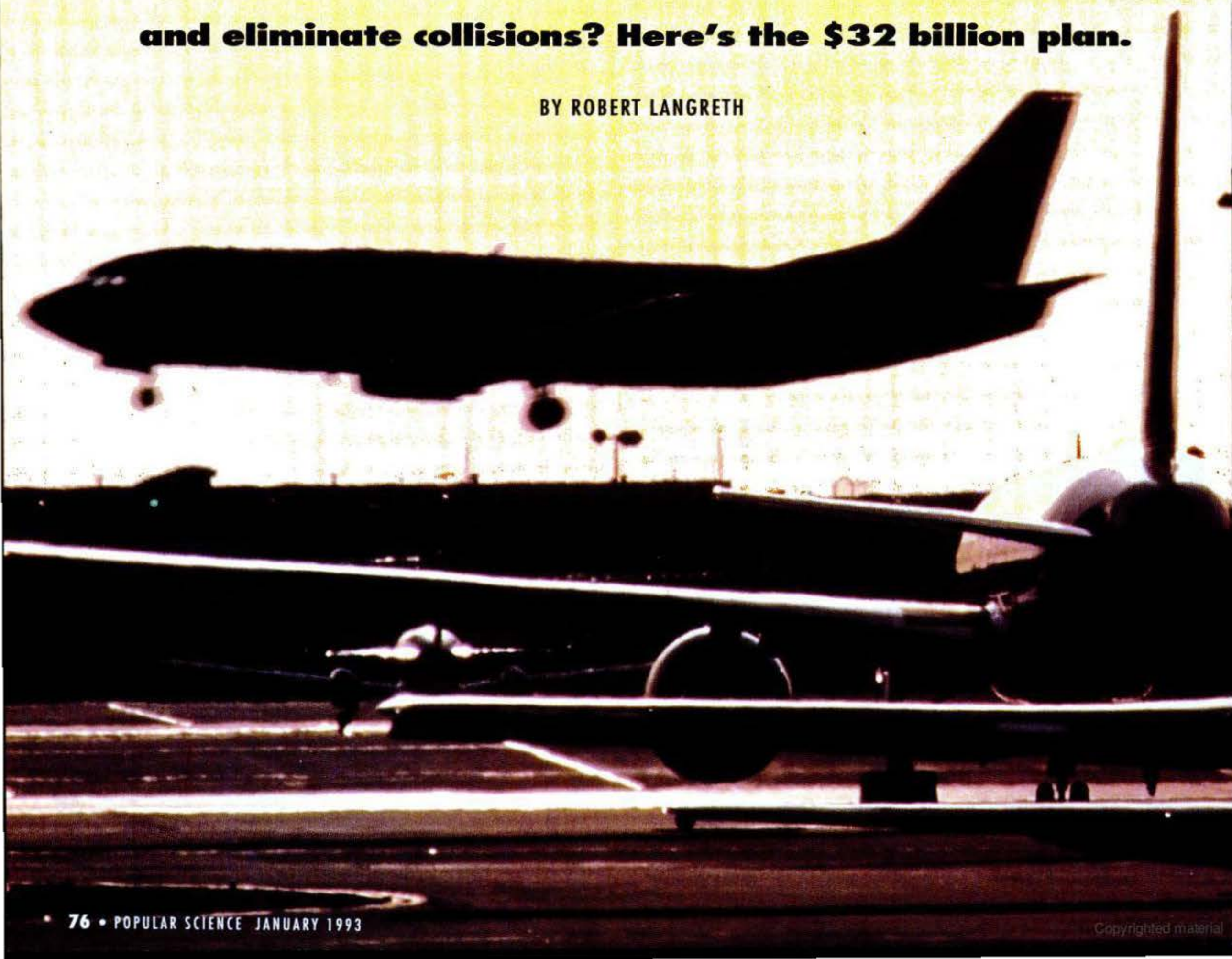
FAIL-SAFE SKIES

COMING IN THE 21ST CENTURY?

With commercial air traffic expected to double in the decade ahead, the FAA is playing catch up. Can it design a highly automated computer control system to reduce delays and eliminate collisions? Here's the $32 billion plan.

BY ROBERT LANGRETH



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The pilot of United Airlines Flight 235 doesn't know it, but 200 miles away, another plane is on a collision course with his airliner. The other jet, approaching at an oblique angle, is too distant for the pilot to see and too far away for a human air traffic controller watching this sector of airspace to notice on his radarscope.

But deep inside a ground-control center, an "intelligent" computer discovers the problem. It quickly calculates the best solution, and with the approval of the human controller, sends the data to the United pilot.

On Flight 235's cockpit computer, a new message pops up: "Descend to 32,000 feet. Turn right heading 286." The pilot complies, and 15 minutes later the planes pass each other with miles to spare. The United captain never even sees the other plane.

Today, this is science fiction. But if the FAA has its way, that won't be for long. Virtually all the technology needed for this scenario already exists, in prototype form, at a laboratory sponsored by the Federal AAviation Administration (FAA) in VVirginia. Dubbed AERA—Automated HEn-Route Air Traffic Control—this computer program is probably the most elaborate part of the FAA's $32 billion plan to automate air traffic control. The product of a decade of intensive development, it can identify and resolve conflicts as much as 20 minutes before they happen.

Automation of air traffic control is sorely needed. Unlike the modern hardware used by pilots, controllers use computers and equipment that is often 20 years old. Meanwhile, U.S. air traffic has increased in the last 20 years from 390,000 to about 900,000 scheduled flights per month. As evidence of this, aviation critics point to several runway collisions or near-misses that have occurred recently, including fatal accidents in 1990 at Detroit and Los Angeles airports. During each of the past five years, U.S. airports have averaged, as a whole, more than 200 close calls on runways.

"We have been relying on human controllers to be machines, and that is idiotic," says John Nance, an aviation writer and FAA watchdog. "Controllers are overloaded, and we're gambling they can remember everything."

Naturally, FAA officials dispute this, pointing out that per mile traveled, flying is still much safer than other means of transportation. But they can't dispute the airlines' horrible on-time record. In 1991, commercial airlines experienced nearly 300,000 delays of 15 minutes or longer. The year before, at the ten busiest airports alone, airplanes were delayed 590,000 hours, robbing the public of a staggering 50 million hours of lost time. The second leading cause of delays, after bad weather, is overcrowded airspace and airports.

With commercial air traffic expected to double over the next ten years, the FAA calls automation "the key" to the future of air traffic control, and it will happen in two stages: During the next five or six years, the FAA will add automated databases for tracking flight information and advanced radar monitors to replace vintage scopes designed in the 1960s.

After that, it will begin installing intelligent programs like AERA. Under the supervision of humans, such programs may someday make 80 percent of routine air-traffic decisions.

"There's no question that the system of the future will have more automation than today," says Joseph Del Balzo, a leading technical officer for the FAA. "I believe we can teach computers to think like air traffic controllers."

In addition to AERA, the FAA is also working on:

- A computer program called the Center Tracon Automation System (CTAS), which predicts the optimal spacing of planes approaching for landing, and advises controllers how to maneuver jets during their descent.
- A voice-recognition computer for control towers that understands controllers' spoken commands to pilots and automatically tracks where the planes are supposed to be. This would

TONY STONE WORLDWIDE

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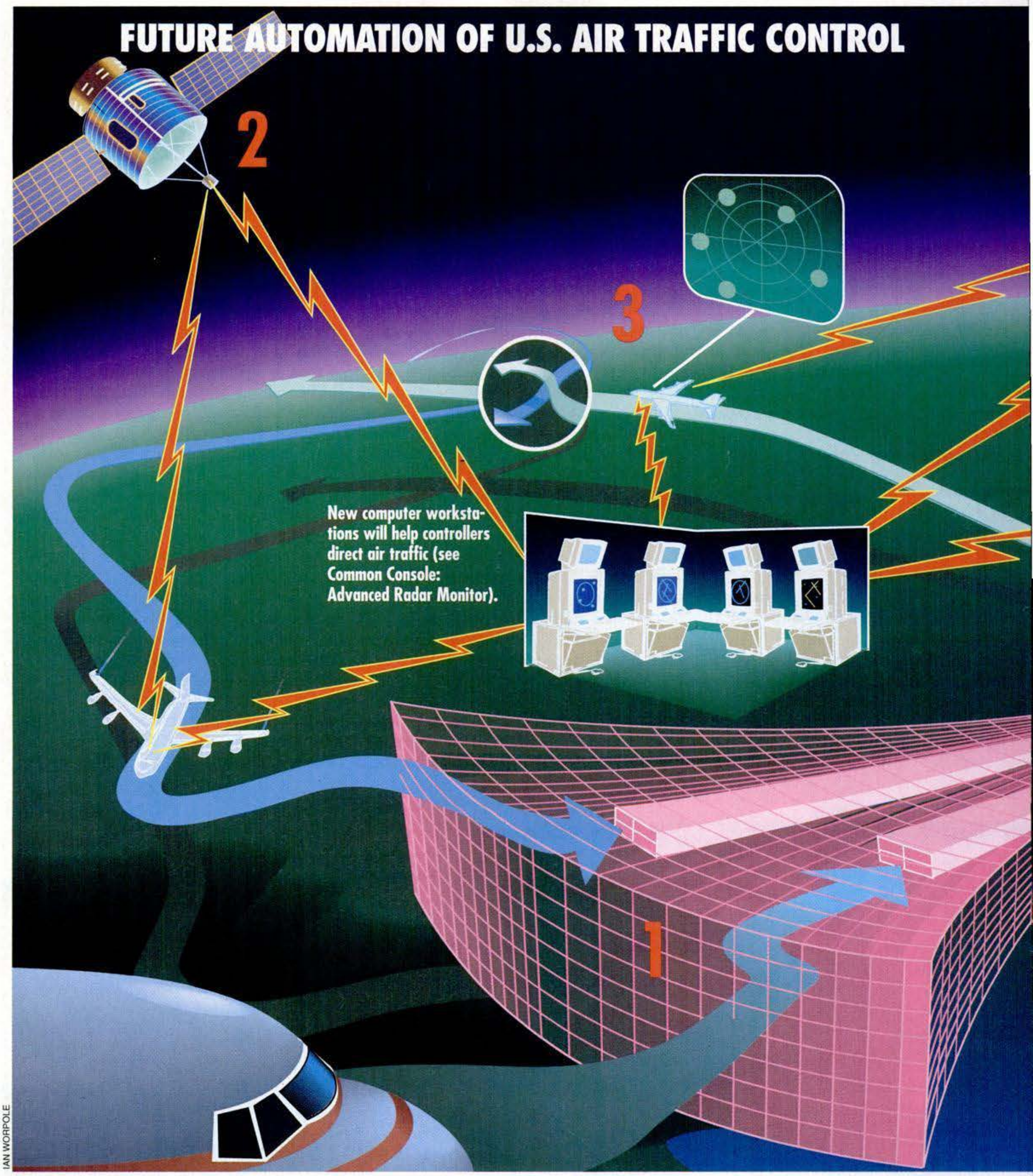
FUTURE AUTOMATION OF U.S. AIR TRAFFIC CONTROL
2
3
New computer workstations will help controllers direct air traffic (see Common Console: Advanced Radar Monitor).
1

IAN WORPOLE

allow controllers to keep their eyes on the airport.

• Direct links between ground and cockpit computers, which will transmit everything from routine landing clearances to up-to-the-minute weather information, freeing up crowded voice airwaves for emergencies.

Automation should have major benefits for both controllers and passengers. "Computers can fly aircraft more precisely than humans," says Martin Pozesky, the FAA's associate administrator for system engineering and development. He estimates that new computers may increase U.S. air traffic capacity by 30 percent, making the skies safer without building a single additional runway.

Over the next decade, advanced computers and other new technologies could revolutionize a controller's job. Today's controller, juggling up to three dozen planes per hour, generally reacts to problems as they happen. In the future, computers will allow them to plan further ahead, preventing bottlenecks.

"The controller will become more of a strategist than a tactician," says Larry Roberts, a Seattle controller who's testing new air-traffic-control computers. This will allow them to chart out more-direct routes than the rigidly controlled paths that aircraft usually follow now.

Ultimately, say automation enthusiasts, the controller could become some-

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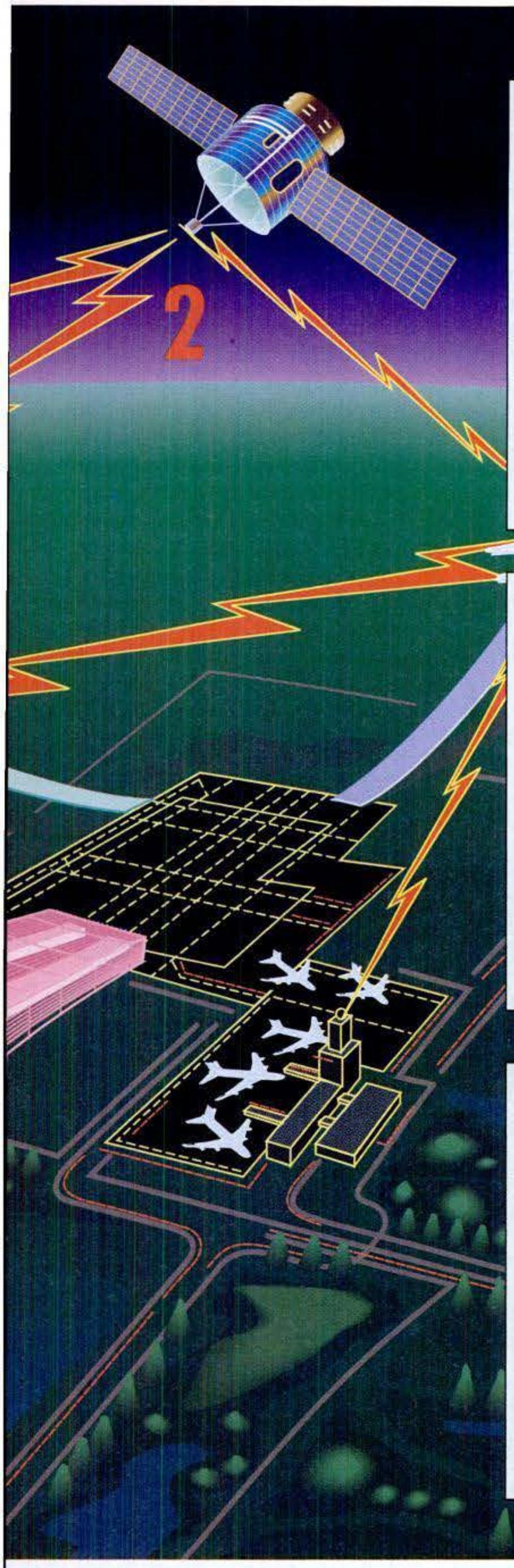

1 MICROWAVE LANDING SYSTEM DEBUTS

Over the next few years, a new system for bad-weather landings may keep airports closer to schedule. After long delays, the Federal Aviation Administration's (FAA) Microwave Landing System (MLS) is finally making its debut. The chief advantage of MLS is that it allows pilots to fly curved landing approaches. Under the current method—the Instrument Landing System—planes must follow a straight, pencil-shaped beacon during the last several miles of flight. Near busy airports, this often creates delays.

In contrast, MLS sends out a funnel-shaped beacon from the runway. As long as jets stay within this funnel, they can approach the runway from any direction they want. MLS may eventually allow planes to perform a Category III—completely blind—landing. "The New York area airports will save between 3 and 19 minutes [per plane], depending on which runways are being used," asserts the FAA's Steven Wolf.

After being postponed for more than five years because of a contractor default, MLS is being installed at 26 U.S. airports over the next two years, starting with Seattle. By 1995, the FAA will decide whether to scale up production to 1,250 runways across the country.

2 SATELLITES FOR LANDING AND NAVIGATION

The Microwave Landing System clearly works, but is it worth the $60,000 to $120,000 it will cost to install in large jets? No, say many airline industry officials. Instead, they favor using the military's global-positioning satellites for poor-visibility landings.

Using an inexpensive receiver, anyone can use this network of 19 satellites (24 when completed by the end of 1993) to locate position within an accuracy of about 330 feet. Coupled to a ground station that corrects for errors, these accuracies can be improved to about three feet. Although the technology is still in its infancy, independent-minded pilots support it because they would no longer have to rely so heavily on ground control.

Satellites will also replace the existing ground-based navigational beacons, which have limited accuracy when planes are far away from them. The first use of satellites for commercial jets, however, will likely be over oceans. Today, planes often must rely solely on their own internal navigation systems. Korean Airlines Flight 007, shot down in 1983 after straying off course over Soviet waters, proved that this can lead to disaster.

3 MIDAIR COLLISION-AVOIDANCE DEVICE

One device for avoiding midair collision is already in most airplane cockpits, and it's prevented at least 15 possible near-misses or midair collisions, according to pilot reports.

Over the last two years, airlines have installed the Traffic Alert and Collision Avoidance System (TCAS) in 60 percent of passenger jets; by the end of 1993 they're required to put it in all their planes. The product of years of development, TCAS scans the air every second for transponder signals emitted by other jets. From these signals the system computes the ranges and velocities of the other jets, displaying nearby planes on a screen in the cockpit. If an aircraft comes within 45 seconds of collision, a voice warns "Traffic! Traffic!" Twenty to 30 seconds before impact, the voice commands "Dive!" or "Climb!"

Although pilots love it, controllers complain that TCAS produces too many false alarms. For example, when a plane is rapidly ascending through a crowded airspace, but about to level off at a safe altitude, TCAS—not knowing the plane's intentions—sometimes wrongly anticipates a collision. The FAA is planning changes to eliminate such glitches.

thing like a supervisor on a high-speed assembly line, deciding how much air traffic different regions can handle, but leaving most of the routine decision-making to the computers. In such a system, Del Balzo speculated in a speech last year, "An aircraft [may] depart its origin along a route predetermined by computer projections, and barring . . . unforeseen [problems], reach its destination without being impeded by any other aircraft, and without any intervention by the air-traffic-control system."

Critics of the FAA don't question the need for automation, but rather the agency's ability to get the job done. Just about every major improvement has been delayed for one reason or the other, they note. For instance, the FAA is two to four years behind schedule in the first stages of its Advanced Automation System (AAS), which includes the new computer monitors for controllers. Until these new monitors are completed in the mid-to-late 1990s, air-traffic-control computers won't have enough brawn to perform advanced functions like AERA.

For its part, the FAA insists it simply underestimated the difficulty of designing and building the new equipment. Critics beg to differ. The FAA has an "inherent tendency to study things to death," says John Nance. As an exam-

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ple, he points to the Traffic Alert and Collision Avoidance System (TCAS), a cockpit computer system for preventing midair collisions ["TCAS: Can it Stop Midair Collisions?" Aug. '88]. First developed in the 1970s, TCAS has been installed on airplanes only within the last two years (see Midair Collision-Avoidance Device). "The FAA did everything they could to niggle, block, dodge, delay, foot drag, and think about something else that should have been put in place" more than a decade ago, he says.

Money—or the lack of it—also hinders the FAA. While the agency is spending tens of billions of dollars on short-term improvements, such as faster computers, it only budgets approximately $200 million each year for longer-range projects, such as AERA. "By any standard [the current level of research funding] equates to neglect," thundered Democratic Representative Tim Valentine of North Carolina, chairman of the House Subcommittee on Technology, at a hearing last March. He's not alone. A blue-ribbon review panel of aviation experts concluded unanimously last fall that "FAA research and development will require substantially increased funding if objectives in . . . safety, capacity, and security are to be achieved."

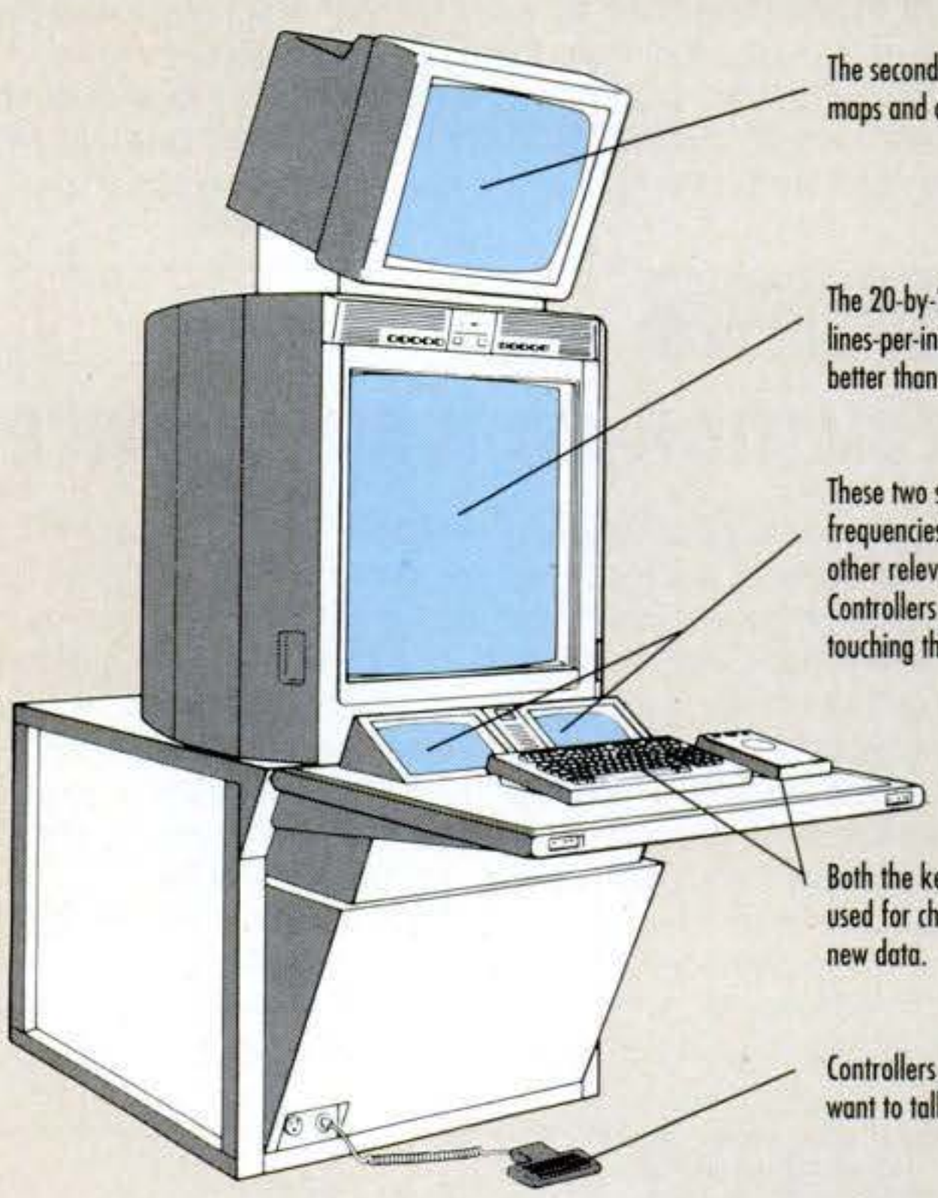
Complicating matters even more, the would-be users of new air-traffic-control technology are often at odds with each other. Pilots want new technology quickly—especially if it decreases their dependence on ground control. On the other hand, controllers prefer a more cautious approach, involving careful training. Says William Faville, director of safety and technology for the controllers' union: "Controllers don't want to have [new technologies] shoved down their throats."

In the United States, serious steps toward automation began in 1981, when the FAA decided its air-traffic-control methods were obsolete and laid out a new vision in its National Airspace System. The plan included several kinds of new computers, better radar, a precision microwave landing system for easier landings in poor weather, and two different kinds of collision warning devices (see Microwave Landing System Debuts; Satellites for Landing and Navigation).

Today, 11 years and numerous delays later, the AAS—the "heart and soul" of the plan—is nearing completion, says Del Balzo. Scheduled to be installed for the most part between 1995 and 1998, it will provide controllers with new computer workstations that will both automatically keep track of basic flight data, such as destination or type of plane, and serve as radar displays (see Keeping an Eye on Busy Runways).

The AAS will make improvements at all three types of air-traffic-control centers. Although most people associate air traffic control with airport control towers, in actuality, control towers manage planes only while they are on the ground and give landing or takeoff clearances. Once planes are in the air, they are controlled either by TRACON (Terminal Radar Approach and Con-

COMMON CONSOLE: ADVANCED RADAR MONITOR


The secondary screen can be used for maps and charts.
The 20-by-20-inch main screen has a 100-lines-per-inch resolution—four times better than standard TV sets the same size.
These two screens list airplane radio frequencies for talking to planes, and other relevant phone numbers. Controllers can select frequencies by touching the screen.
Both the keyboard and track ball can be used for changing displays or bringing up new data.
Controllers push a foot pedal when they want to talk to pilots.

This computer workstation is called the common console because it combines the functions performed on many different machines today. By 1998, it will be used at both approach control and en-route air-traffic centers; each center will contain many common consoles connected to a central computer. The console's large main screen can be switched between a radar-display (bottom right) and flight information display (top right). In the radar-display mode, controllers can zoom in on an area of particular interest. Furthermore, the flight-information display is color-coded to help controllers distinguish between and assign priority levels to various airplanes.

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trol) facilities, usually located near major airports, or by en-route centers scattered across the country. TRACONs direct planes during their final approach or initial ascent, while the en-route centers direct planes at or near cruising altitude.

Currently, the controllers at all three types of air-control centers trace this information with typewritten strips of cardboard about the size of an office name tag. At an airport, for example, controllers will line up these strips in the order of scheduled takeoff.

Although the FAA insists this method works, it's not exactly a reassuring system. What happens if one of these strips somehow gets lost?

That, in fact, is exactly what happened at Los Angeles International Airport on Feb. 1, 1991. That night, a USAir 737 landed on top of a Skywest commuter flight, which had been cleared onto the same runway by the control tower, killing 34 people. The cause: A flight strip for a third jet (not involved in the accident) had been misplaced, causing a controller to "misidentify an airplane and issue . . . a landing clearance that led to the runway collision," according to the National Transportation Safety Board.

The AAS computers should make it nearly impossible for controllers to make such errors, say officials at IBM, the chief contractor for the project. Perhaps the most dramatic part of the AAS will be in airport control towers, where the computers will track planes by listening to a controller's voice.

A recent demonstration at an IBM laboratory in Gaithersburg, Md., suggests how the control tower of the future will work. When a controller is about to give a command—such as "United 456, pull back from the gate and proceed to Taxiway 4C"—he will press a button on a joystick. This, an IBM engineer showed, activates a voice-recognition program that "understands" the limited set of commands controllers use. After hearing the controller's command, the computer will move United 456 out of its list of planes at the gate and into a list of planes on the taxiway.

If a controller forgets where a plane is supposed to be, this information can be called up on the computer by pressing another joystick button. Controllers won't have to take their eyes away from monitoring the airport for more than a few seconds. "We expect this to have considerably greater accuracy than other voice-recognition computers"—at least 98 percent, Doug Miller, an IBM engineer, told me. "I don't know any study that has shown typing [paper strips] to be this accurate."

For controllers who handle planes once they're airborne, the same computer that manages flight data will also serve as a new high-tech radar monitor. Unlike today's radar scopes, which indicate airplanes with green smears, the new computers show the precise location of airplanes on high-resolution, seven-color screens.

Today, each air traffic controller manages a small region of airspace (generally, several thousand square miles), but has no simple way of knowing how commands to planes in his region will affect traffic patterns in other regions. Thus, a controller's actions can have unintended consequences. Ordering a plane to turn right ten degrees, for instance, may solve an immediate problem, but cause a more serious jam-up in another controller's sector 15 minutes later. For the first time, the new computers will allow controllers to monitor the regions of airspace adjacent to their own—preventing such difficulties.

The scope of these projects combined is staggering. IBM has written more than two million lines of computer instructions for the different parts. Also, the new radar monitors and databases are required to be 99.99999 percent reliable. That's only three seconds of failure per year—hundreds of times better than existing air-traffic-control computers. "It's the largest computer project of its sort ever," says Del Balzo.

By the late 1990s at the earliest, the FAA hopes computer programs will be making some decisions for controllers. The AERA prototype, which I saw demonstrated at a Mitre Corp. laboratory in McLean, Va., shows how this will work.

AERA consists of hundreds of thousands of lines of computer programming language. From radar returns, AERA receives aircraft locations, altitudes, and velocities. Combining this information and the wind speed predictions for the area in question, it then projects the aircraft courses as much as

[Continued on page 86]

KEEPING AN EYE ON BUSY RUNWAYS

Despite two deadly runway collisions between planes in the last two years, most major airports still don't have radar that can watch planes on the ground.

Only 13 airports are equipped with such radar equipment, and they are stuck with a vintage device designed in the late 1950s. Called ASDE-II, it features a low resolution that makes aircraft difficult to distinguish, and worse, it often fails during stormy weather. "It really stinks," says a controller at New York's John F. Kennedy Airport. "When we need it most it doesn't work."

This sorry situation is starting to change. Last summer, the Federal Aviation Administration (FAA) began introducing a new, more reliable ground radar at 29 major airports. Built by Norden Systems in Norwalk, Conn., the new equipment uses radar pulses at 16 different frequencies, rather than just one, giving it a vastly increased resolution, says Armand Maillet, an FAA engineer.

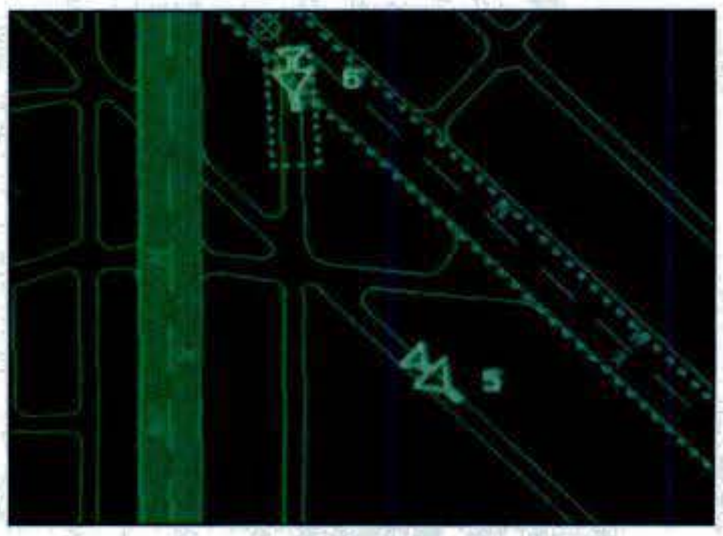
While the old radar showed aircraft as tiny blips, the new radar can distinguish parts of aircraft, such as the wings and tails, and can even detect humans walking on a runway. "It's 100 percent better," says Pittsburgh controller Tim Haines, who has tested the new radar.

It should also work in bad weather. Currently, radar antennas are protected by a stationary dome, which gets covered with water during storms, interfering with the radar signal. The new radar dome rotates along with the antennas, preventing water from building up.

Like some other FAA modernization efforts, the new radar has been plagued by technical glitches. Most problematic, when controllers activate a feature that zooms in on a particular region of the airport, the radar often gets double vision, dividing longer jets into two or more separate planes.

Once the radar is fully functioning, the FAA is planning some improvements. Norden is developing a computer program that will determine if two aircraft have accidentally entered the same runway and alert the controller with a message like WARNING. POSSIBLE RUNWAY INCURSION. Also, the radar information may be transmitted to planes and displayed on cockpit computers, further reducing the chance of collisions.—*R. L.*

JOHN B. CARNETT



It's hard to distinguish planes on the old radar (top), but not on the new version (bottom).

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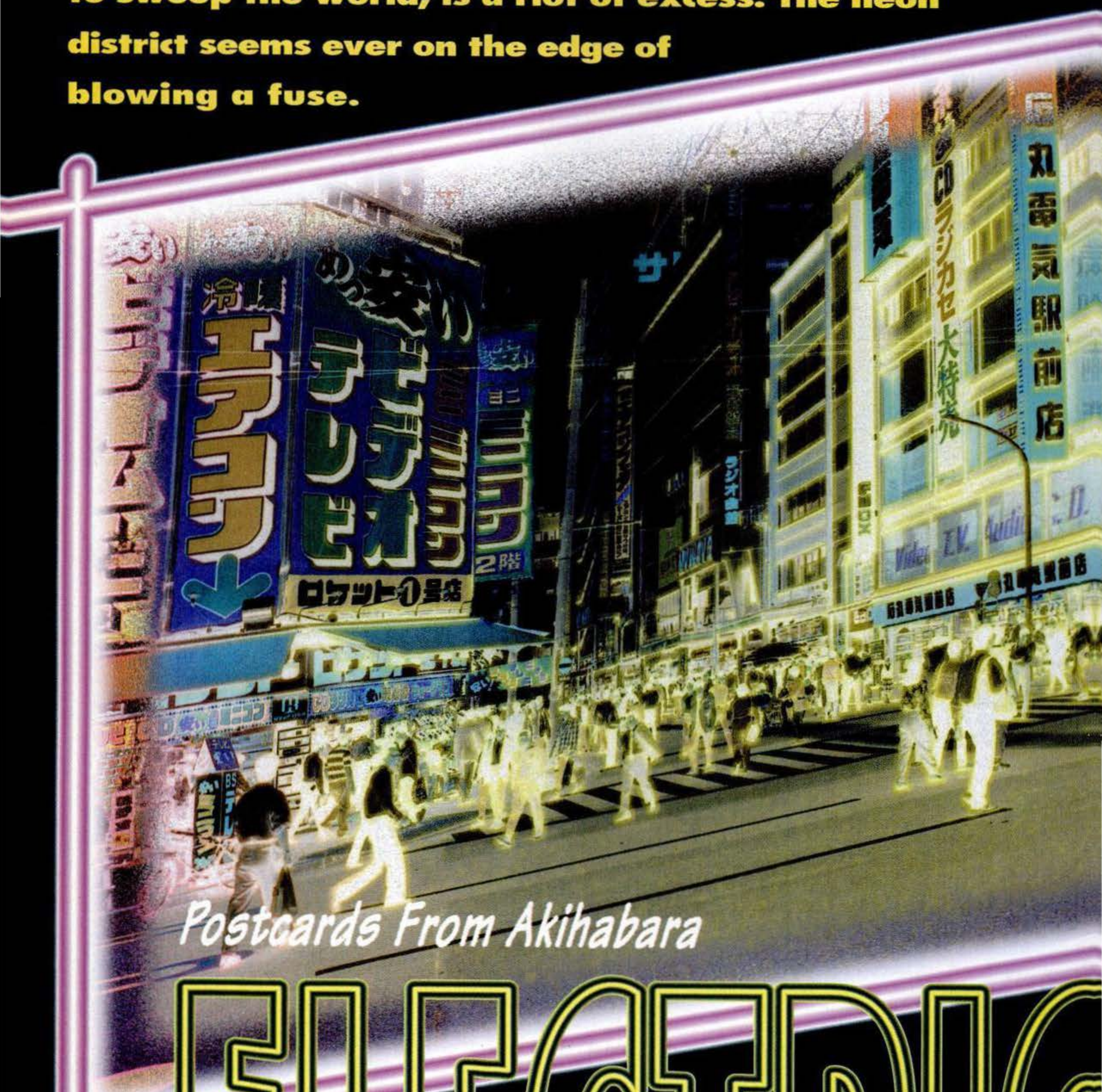
Akihabara, *the* place to see electronics technologies about to sweep the world, is a riot of excess: The neon district seems ever on the edge of blowing a fuse.



Postcards From Akihabara

ELECTRIC

BY DENNIS NORMILE

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CITY

Clustered around this Tokyo train station are hundreds of stores hawking gadgets and gizmos that may never show up anywhere else: a pogo stick that counts the number of hops on a battery-operated digital display; "fuzzy-neuro" washing machines claiming to have hundreds of wash cycles; countertop dishwashers that hold no more than a dozen plates; a combination turntable, cassette deck, and CD player the size of a large lunch box; and a MIDI fax machine that will send a tune played on one electric piano over phone lines to another.

Storefronts are eye-wrenching collages of neon signs and fluorescent-painted banners. Every TV is playing, every air conditioner blowing, every speaker blaring. The city itself seems to run on pure energy.

Akihabara is *the* place to see technology that is about to sweep across the world. Digital-audio-tape gear was on the shelves years before it showed up overseas, and Sony's Data Discman was on sale for more than a year before the U.S. version was available. The current view of the future seems to be high-definition television (HDTV). All the major stores have HDTV sets showing the eight hours of programming broadcast daily.

Every model of liquid-crystal-display TV and every camcorder is lined up for comparison. There are stores that sell only computers and stores that handle nothing but electronic musical instruments. Check out $70 headphone tape players on street corners or privately audition $70,000 stereo systems in cozy, soundproof listening rooms.

Gadgets galore

On display in Yamagiwa Corp.'s Audio Cellar are the finest audio components and speakers from Japan, the United States, and Europe. Customers select the equipment they want to hear and return for a demonstration on an appointed day when it's installed in the living-roomlike Audio Fitting Room.

City lights

Old and unusual equipment can be found too. Hisako Uchida sits on a stool in a six-foot-by-six-foot stall in the Radio Center—a 40-year-old three-story building wedged under the elevated train tracks—where she is surrounded by waveform monitors and signal generators. The stall's specialty, however, is no-longer-made vacuum tubes that Uchida's husband, Hideo, bought up as they were being discontinued. People come from all over Japan and even from overseas looking for vacuum tubes, says Uchida.

[*Continued on page 85*]

Wacky watches

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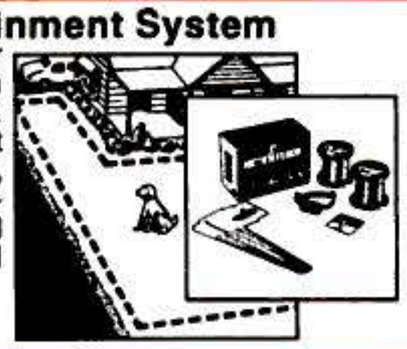

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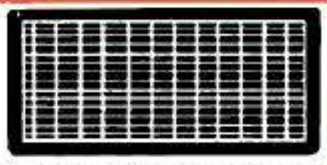

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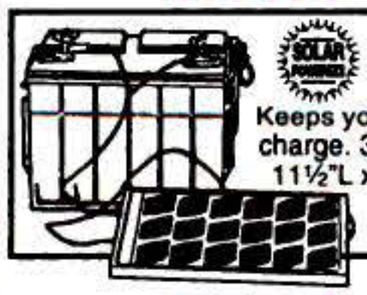

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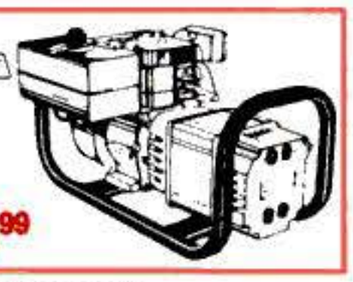

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Cracking the code

[Continued from page 74]

of arithmetic, he can check whether his guess is correct. He gets the message and he gets your key, which would enable him to use your key from then on. You don't need very sophisticated techniques to mount this attack." The government has not responded to the Bellcore objections, adding to speculation about Orwellian intentions.

Given concerns about DES and the government's motives, the computer industry is trying to agree on a new standard without the official backing of the government. The system eliciting the most interest is a method of encryption that does not depend upon the easily intercepted exchange of a password.

Many of the largest computer hardware and software companies have already licensed the RSA Public Key Cryptosystem, which can be used in concert with DES. RSA is named after its inventors—Ronald L. Rivest, a computer scientist at the Massachusetts Institute of Technology (MIT); Shamir; and Leonard M. Adleman, a mathematics professor at the University of Southern California who recently served as a consultant for *Sneakers*. All three were professors at MIT when they devised the system in 1977. The university licensed the patent to them in 1982, and they formed RSA Data Security in Redwood City, Calif., to market the technology.

Two keys are better than one

Instead of a single key that must be shared between users, the RSA system has a matched pair of keys. One key is private, and the other is public. The public key is published in a directory, allowing people who have never met to send messages to each other. The public and private keys perform inverse functions: What one does, the other can undo.

Under the RSA protocol, as with DES, a document is first converted into numbers. Using the public key, these numbers are raised to frighteningly high exponential powers and divided by the product—at least 150 digits long—of two prime numbers. The remainder of the fraction is the encrypted bit of information. Only someone with the private key, which contains the two prime numbers, can compute the remainder and decode the message.

The system relies on the difficulty of factoring a large number back to two prime numbers—numbers that can be divided evenly only by the number 1 and themselves (3, 5, 7, 11, and so on). It is easy to multiply two large prime numbers together, but hard to factor their product back to its two components. In October 1988, for example, it took an international group of computer scientists nearly a month to factor a 100-digit number. More than 400 computers worked on the problem during idle hours to find the number's two factors—one 41 digits long, the other 60 digits long. In June 1990, another team factored a 155-digit number. The number was handpicked to make the task easier, but it still took 275 years' worth of computer time. To keep pace with ever-faster computers, RSA's inventors can simply add more digits to the system's keys.

RSA and DES are not competitors. In fact, RSA could help prevent DES from becoming obsolete. Because it takes a long time to encrypt an entire message with RSA, the system is typically used to encrypt a DES key. That key is then used to encrypt the rest of the message. "RSA lets you use a different DES key for every message," explains James Bidzos, president of RSA Data Security.

A new government standard?

In the coming months, NIST will decide whether DES will remain as the standard encryption method used by federal agencies. Because the new "digital signature" standard proposed by NIST is under fire, the Commerce Department's computer security advisory board has recommended that the standards institute delay its decision until June of this year.

The computer industry would like NIST to adopt the RSA technology, but that isn't likely to happen. One reason: If the privately developed technology becomes a standard, the government will have to pay royalties for its use. And perhaps more important, the NSA does not want the government to back the RSA encryption system. The agency has already conducted private negotiations with the Software Publishers Association, which represents computer software makers, regarding the export of programs containing encryption features.

"[The NSA] dislikes our system because it's too hard to break," says Bidzos. "They clearly don't like what we do, but we're succeeding in spite of that."

The power of RSA's approach has already spread, through unknown channels, to foreign enemies. Iraqi generals are believed to have used RSA encryption during the Persian Gulf war, and the technology is indisputably on the move throughout the world. Perhaps the only good news is that American generals had the same RSA technology in their laptop computers. PS

Electric city

[Continued from page 83]

In many ways the heart of Akihabara is the Radio Center. It is a rabbit warren of tiny one-person booths crammed with diodes, capacitors, transistors, and switches laid out in small bins like penny candy. Customers select a few transistors, say, and a diode or two, and place them in blue plastic trays before paying. "The most famous part of Akihabara is those small stores packed under the railroad," says Go Sato, an official with an area merchants association.

Sato explains that after World War II many merchants worked out of carts parked in the streets of Sudacho, an area about a mile from Akihabara and not far from what is now Tokyo Denki (electric) University. "The college students would search through the stalls for electronics parts and assemble radios, which they sold," Sato says.

Mah-nee-ah

At its peak, the Sudacho street market had around 150 stalls. But in the late 1940s, the occupation authorities disbanded the markets because they had grown too large, blocking traffic. The merchants moved into the buildings under Akihabara's railroad tracks. "Akihabara became the place for electrical goods," Sato says. Now, Akihabara's 500 to 800 shops account for about 10 percent of all the electronics goods sold in Japan. Each weekday roughly 75,000 people pass through, spending $4 billion to $5 billion a year. Browsers range from tourists to corporate engineers looking for odd parts for prototypes to enthusiastic hobbyists with electronics mania—or, as it is pronounced in Japanese, *mah-nee-ah*.

Dashing through the narrow aisles is Kenny Sheen, a Japanese editor and translator. He admits he knows his way around, but denies he has any sort of *mah-nee-ah*—after all, he only comes to Akihabara once a week. "I don't always buy. I just like to check out the prices," says Sheen. When he does buy, he prefers the small stores. "The small shops are better," he says. "You can bargain."

Akihabara is one of the few places in Japan where you can haggle over prices. Merchandise tags give the manufacturer's list price in black, with a line through it. The shop's discount price is in larger red figures—also crossed out. Ask a clerk for the store's best price and after a quick computation on a pocket calculator he'll show you the display as if he's not supposed to mention such low prices out loud.

Not that the prices are that low; what brings travelers to Akihabara are the wacky gadgets and wild energy. PS

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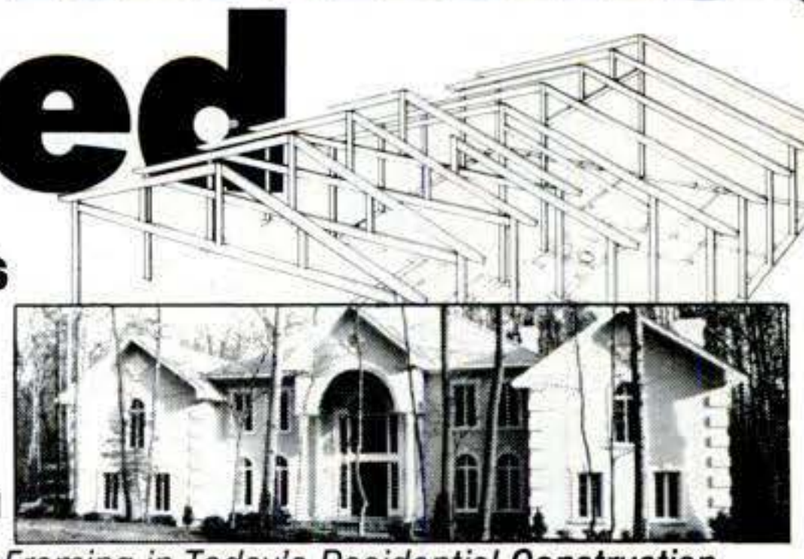

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Fail-safe skies

[Continued from page 81]

20 minutes into the future. When it discovers an impending conflict it indicates the expected collision (or near-collision) course in bright red lines on the controller's computer monitor.

Next, it looks for a solution that alters the airplane's course the least amount, according to specific priorities. For example, a plane that has already started to descend for landing shouldn't be forced to climb again, if at all possible. AERA then ranks the solutions according to the priorities and displays its choices to the controller, who decides what to do.

Controllers who have tested the system are generally enthusiastic. "AERA's going to redefine the types of things controllers do," says Philip Kain, an air-traffic-control manager from Leesburg, Va., who has been testing AERA. Rather than having to spend all their time making sure aircraft don't hit each other, he says, controllers will be able to spend more time assigning planes more direct routes or finding the most fuel-efficient altitudes.

Landings like clockwork?

AERA works well for ensuring airplanes at or near cruising altitudes stay safely separated. However, it doesn't address the most difficult problem in aircraft control: maneuvering planes on approach for landing. At major airports, controllers must channel dozens of planes converging from different directions onto just a few runways. Even a small mistake can cause delays—or collisions.

For this job, the FAA is counting on CTAS, currently being developed by aviation scientist Heinz Erzberger at NASA's Ames Research Center in Moffett Field, Calif.

"CTAS mimics what the controller normally does," says Erzberger. There's one difference, though: Instead of relaying commands directly to aircraft, CTAS makes recommendations that appear on controllers' computer screens; the controllers then decide whether to take the advice.

Starting as much as 200 miles away from an airport, CTAS checks radar returns. The program then suggests what order planes should land, estimates arrival times, and recommends how to space aircraft as close together as safety permits. As aircraft come closer to an airport, the program informs controllers when aircraft should make turns, speed up or slow down, and descend. Like AERA, it also checks for future conflicts.

But the software also can do things that busy controllers simply don't have time for, Erzberger explains. Among other capabilities, it can adjust for airlines' preferences in how to fly. Airline X may prefer to descend at a faster rate than airline Y, for instance.

During tests simulating Denver's approach control center, a CTAS prototype increased airport landing and takeoff capacity about 10 percent. Experts say that even such a small change in capacity makes a big difference in delays. If the number of landings and takeoffs at Chicago's O'Hare International Airport declines 20 percent from normal, for example, "it's a disaster," according to United Airlines captain and chief of systems development Bill Cotton. Most flights that day and even some the next day fall behind schedule.

And there's another benefit to CTAS: safety. "You're more likely to lose safety margins when controllers are distracted [by heavy traffic]," says Chuck Johnson, an FAA air-traffic-control specialist. By reducing stress, CTAS may prevent incidents like the 1986 midair collision between a small private craft and an Aeromexico jet over Cerritos, Calif. In that incident, a busy controller failed to notice that the smaller plane had entered restricted airspace without permission. All 67 people aboard both planes died.

Computer conversations

In their current forms, both CTAS and AERA make recommendations to controllers, who then relay their decision to pilots by voice radio. In the future, however, more of the talking will be done between computers.

"Voice communications are archaic," says Nance. "As long as we're dependent on human brains to understand what is stated, we run a high risk of making mistakes." A second problem, say pilots, is that airwaves often get so jammed with controllers relaying instructions that pilots can't break through even in an emergency.

Computer data links between planes and air-traffic-control centers will ease both of these hazards. Already such links are being used while planes are on the ground. Most airports, for example, now transmit preflight clearances to planes via computer while they are at the gates, freeing up radio frequencies for less mundane transactions.

In the next several years, a variety of new devices—based on either radar or satellite technologies—will let controllers transmit routine information, such as weather forecasts, directly to airborne cockpit computers, say experts. These computer links will also perform tasks that humans cannot. CTAS, says Erzberger, can receive continual updates on aircraft weight, which decreases as a plane burns fuel, from cockpit computers, allowing it to chart more fuel-efficient courses.

Eventually, all ground-to-air communications may be conducted between computers, with major benefits. One study done at NASA's Langley Research Center in Hampton, Va., for instance, found that doing so reduced confusion between pilots and controllers by a factor of seven. "I think pilots are very surprised by how many errors and repeats there are [with spoken communications]," says Charles Knox, one of the authors.

No subway in the sky

Will we ever completely automate air traffic control? Most experts say no—at least for the foreseeable future. "There are huge uncertainties involved in predicting air traffic control," says Jerry Welch, an electrical engineer and aviation expert at Lincoln Laboratory in Lexington, Mass. Runway changes, thunderstorms, and other emergencies all can and do occur unexpectedly. "It's not like a subway system," he says.

Nor have computers proven reliable enough to trust when lives are at stake, say many others. On Sept. 17, 1991, a single faulty instruction in a computer program caused much of AT&T's long distance telephone network to shut down, leaving millions of customers stranded without phone service. Two of these customers happened to be the air-traffic-control centers for the New York City area, which lost communications not only with other control centers, but also some planes. (The centers were able to improvise makeshift phone connections.)

For its part, the FAA agrees that humans will always "exercise management and control" over computers, according to a 1991 concept paper. Nevertheless, top FAA officials like Martin Pozesky think automation will improve virtually every aspect of air traffic control.

Now over Denver, United Flight 235 has run into turbulence. Using a menu on his computer monitor, the pilot sends a message to a ground computer: "Encountering turbulence. Request new altitude." The ground computer first checks possible new altitudes for conflicts with other planes, then examines up-to-the-minute weather conditions that previous planes passing through the same area have provided.

A second later, a message pops up on the pilot's screen. "United 235, climb to 34,000 feet and continue heading 245. Weather data indicates clear skies ahead." PS

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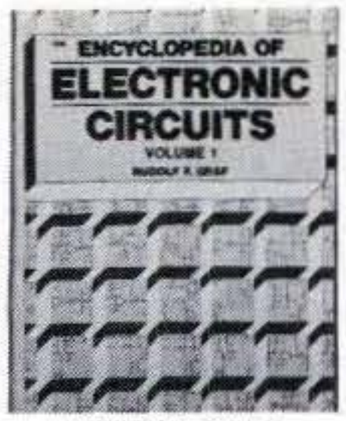

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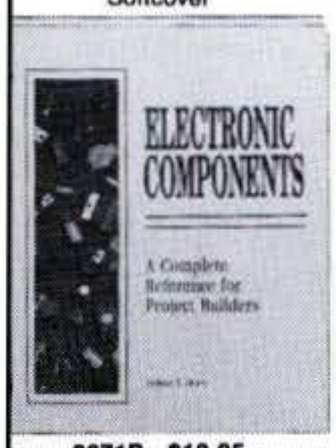

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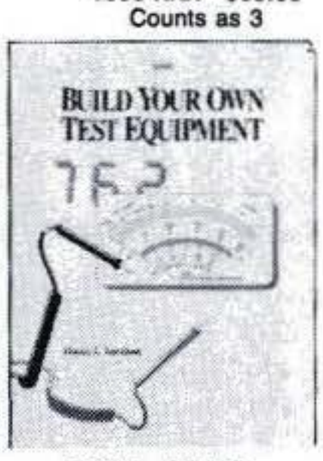

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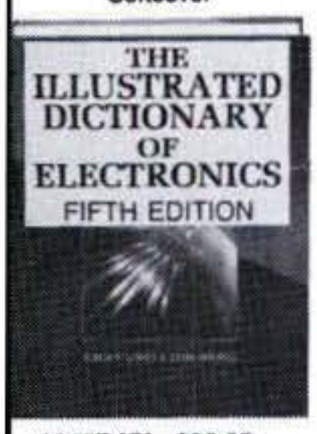

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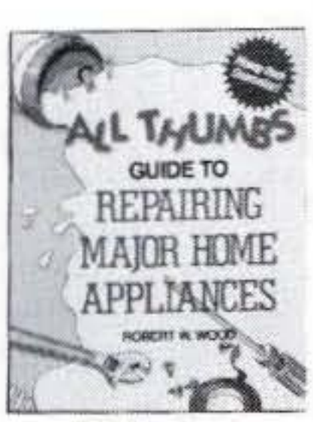

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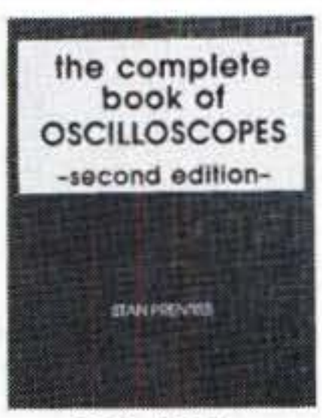

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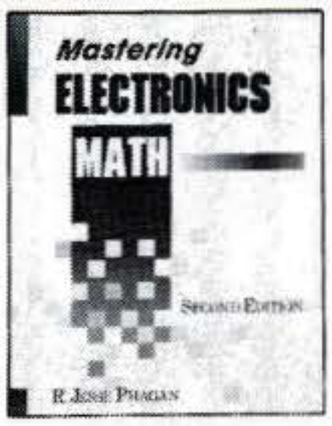

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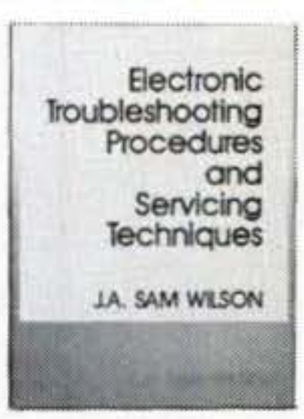

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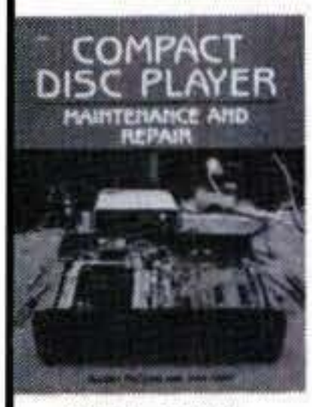

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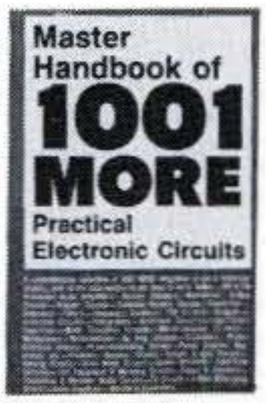

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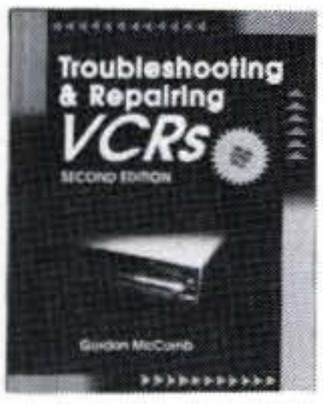

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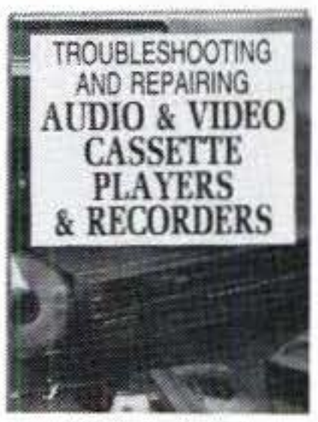

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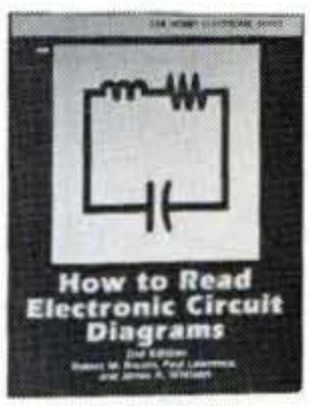

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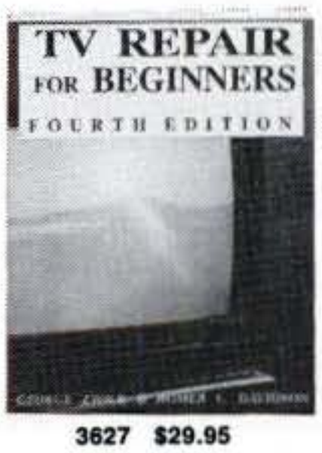

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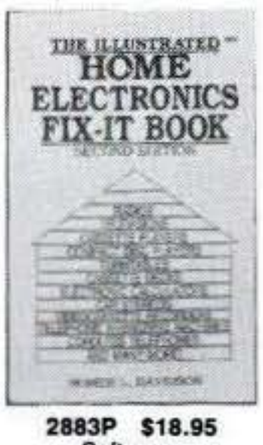

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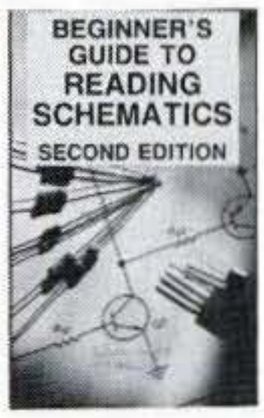

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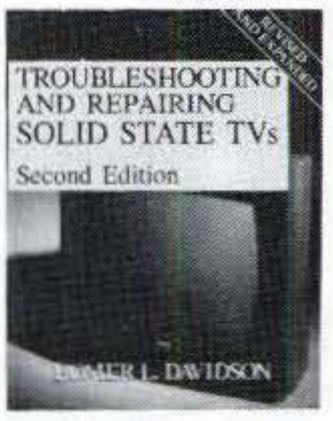

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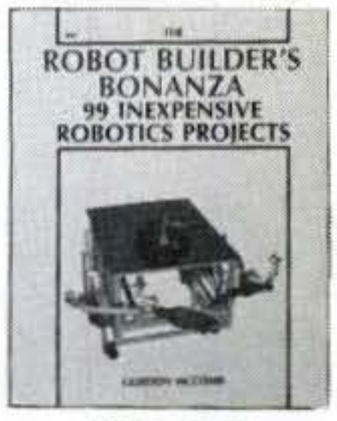

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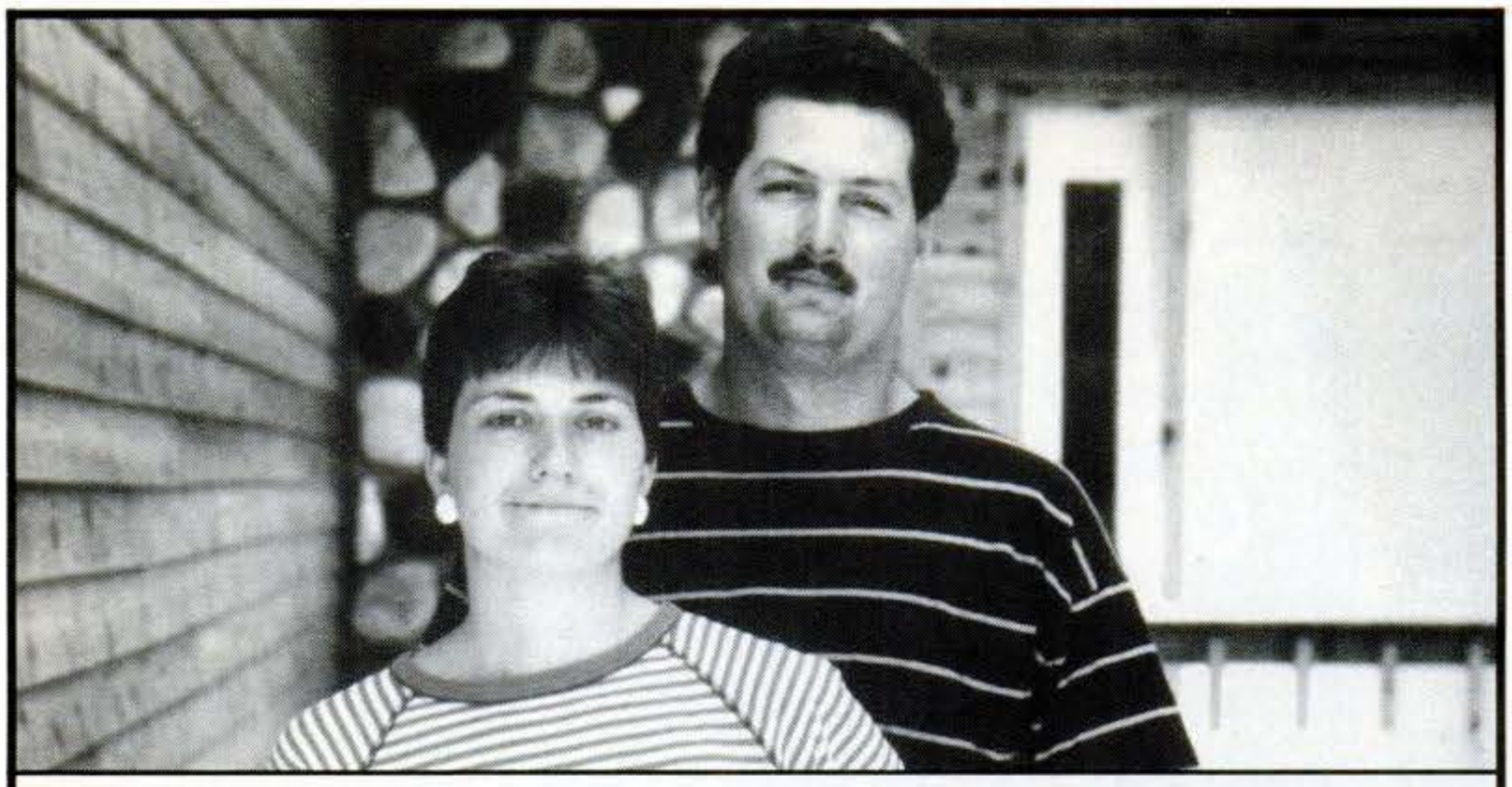

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The house that junk built

[Continued from page 63]

Orville Lee's plan specifies rooms laid out so that many of the standard-size building products do not have to be cut to fit. This also saves construction time.

The next step is using recycled materials, which today are comparable in cost and quality to those made from virgin materials. The Research Center discovered dozens of such products, including "lumber" that combines plastic grocery bags and used pallets ground into sawdust, ceiling material made from old newspapers, and siding produced from mill waste.

One of the biggest resource-savers was the house's steel frame, made from demolished bridges and junk cars, says architect Lee. Unlike wood, he says, "Steel is always specially cut at the mill," eliminating scraps. At a visit during construction, the mass of glinting steel overhead also provided a striking contrast to the usual wood "stick" framing.

The house's roof ventilation system is formed from recycled plastic soda bottles. As it saves energy by releasing hot attic air in summer, ventilation also prevents rot-causing moisture buildup. The vent works well with the house's Nailite plastic roofing. The roofing is made from recycled computer housings; the soffit guards on the house are made from the same material as the vent.

Wrapping up the leftovers

Not all construction waste could be eliminated through planning or using resource-efficient materials, however. The remainder, a mixture of fast-food wrappers from the Maryland construction crew's meals, odd bits of wire, and other scraps, presented its own problems. The major one: finding corporations and hauling contractors to participate in recycling the waste, according to Steve Scully, senior engineer at the center. "There are more than 200 dumpsters in this county [of Prince Georges] and only one is segregated for wood, cardboard, and steel," he explains.

This won't be a permanent problem, says Scully. "The cost of dumping at a landfill for [construction waste from] a residential site is about $500 now," he says.

Costs will likely rise, however, if the EPA determines that construction landfills are just as toxic as municipal ones—and consequently also would require the same types of costly linings. "When the price of dumping at construction landfills rises," notes Scully, "builders will turn to recycling their waste." PS

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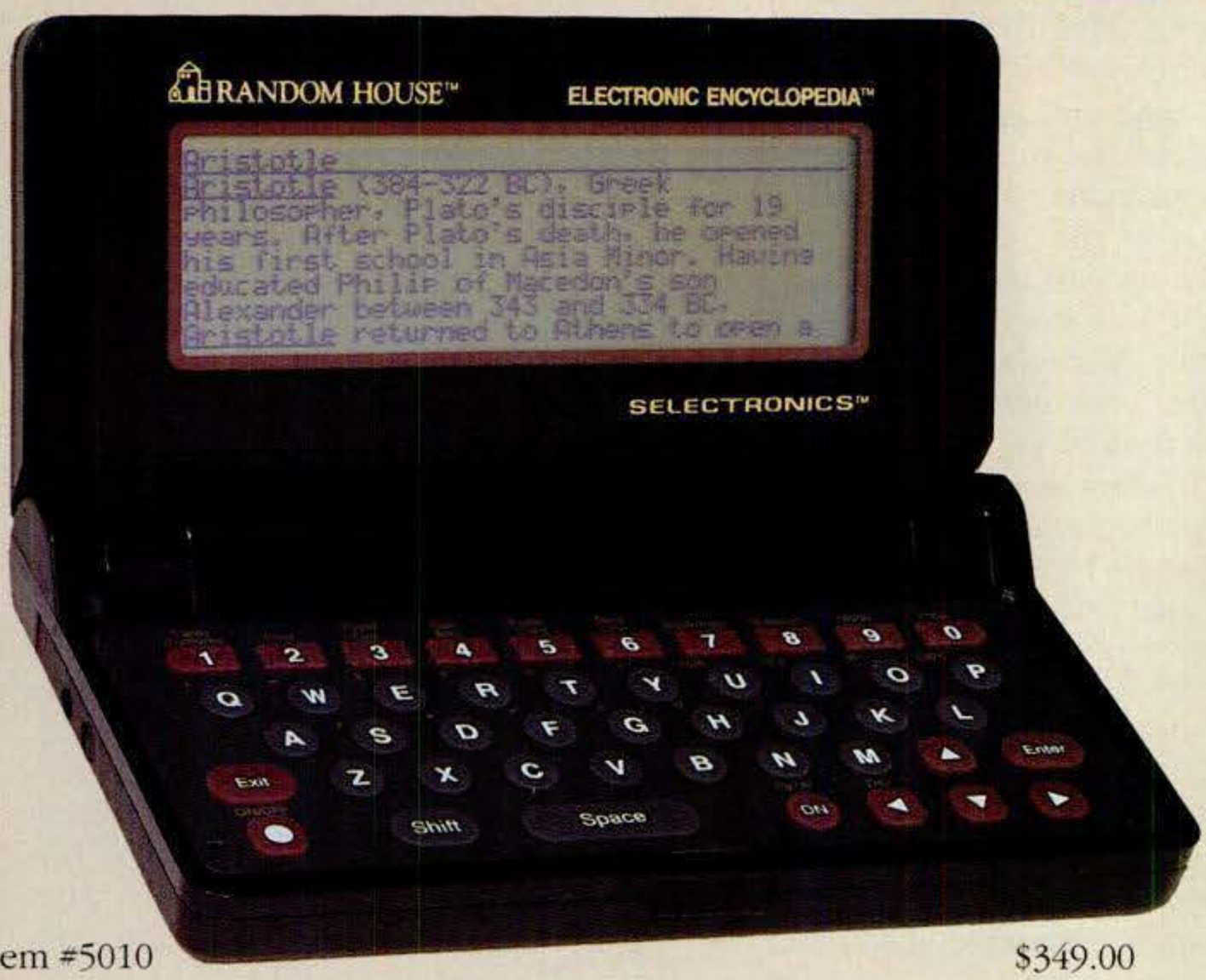
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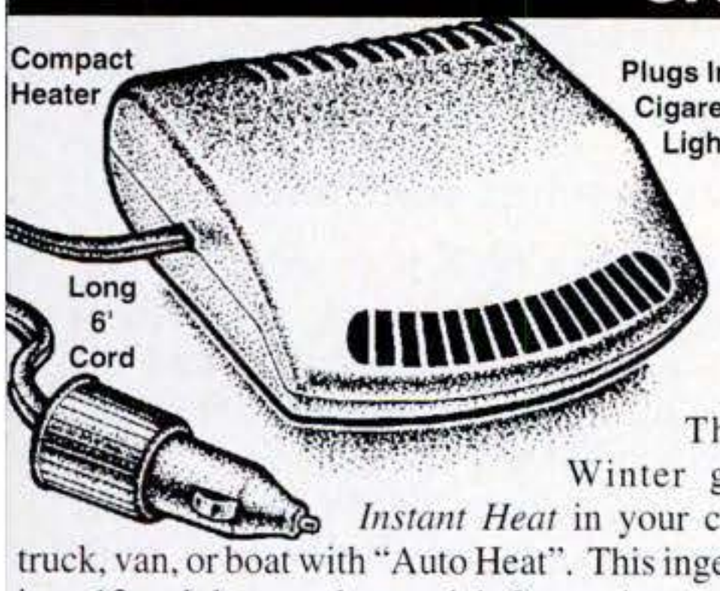

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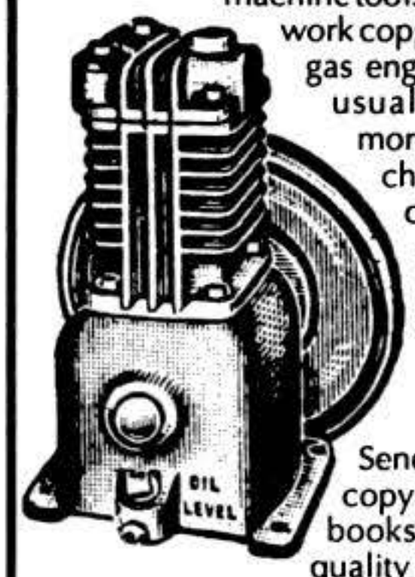

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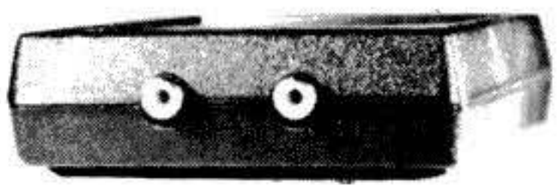

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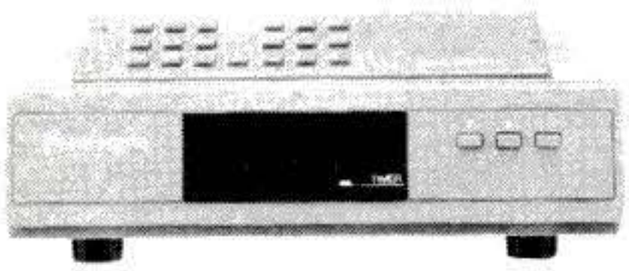

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Stalking stealth viruses

[*Continued from page 58*]

American Megatrends, a leading maker of PC motherboards, has taken a step in that direction. AMI recently modified its basic input-output system (BIOS)—software on a programmable memory chip that directs traffic between the operating system and the hardware—to prevent boot-sector viruses like Michelangelo from writing to the boot sector of the disk. Award Software is doing the same with its BIOS software, and Phoenix Technologies plans to add the boot-protect feature in a future version.

But PC security can be a hard sell. Hardware makers say there's still little demand for security features and that PC users may balk at a hardware solution that forces them to change their ways. Dell Computer Corp. in Austin, Texas, for example, is considering adding virus checkers to the read-only memories of some of its forthcoming systems, but the company doesn't foresee any fundamental hardware changes in the near future. "The reality is that many users are willing to take the risk of getting a virus rather than have something that interferes with their day-to-day use of the computer," says Michael O'Dell, vice president of product development at Dell.

Potential danger

The risk of encountering a virus is still remote. Only about one PC in 1,000 contracts a virus every three months, according to an ongoing study being conducted by the High Integrity Computing Lab at IBM's Thomas J. Watson research center in Hawthorne, N.Y. In the grander scheme of security issues, viruses still take a backseat to human errors and equipment failures.

The potential for damage posed by computer viruses, however, is unparalleled. The proliferation of computer networks and dial-up information services makes sharing software—and spreading viruses—much easier. The new emphasis on stealth technology makes it more likely than ever that a virus could quietly spread across a large number of computers and wreak havoc on the machines that manage many aspects of daily life, from a corporation's quarterly budgets to a hospital's records.

There's a less apparent danger as well. "Viruses threaten to rattle the underlying confidence people now have in computers," says Peter Tippett, president of Certus International, a Cleveland-based publisher of anti-virus software. "And if people stop relying on computers, that's everybody's problem." PS

Sixes

[*Continued from page 68*]

though the variable-assist power steering provides slightly less feedback than might be desired. There has been a lot of work done to tame BMW's rear suspension, and today's multilink design stays in line at the limit, when an older BMW's rear bumper would be attempting to pass you in a corner. The dynamics of the car benefit from the rock-solid body structure, which never seems to reverberate or respond with more than a solid thump over the worst potholes.

There is a basic simplicity to the design, with loads of developmental effort spent on the details—effort that ends up reflected in the $30,000-plus price tag. The 325is defines the conservative approach to a high-performance sedan. Not much about the basic elements of its design concept can be described as avant-garde, but then again there is nothing much in the way of a technical tidbit that hasn't been at least considered before being discarded. The result is a basic, high-performance, extraordinarily well-built sedan that gets modest fuel economy, is faster than most, and has handling superior to most flat-out sports cars.

Volkswagen's Corrado is at the opposite extreme—a highly specialized mini-coupe that offers sports-carlike handling with limited accommodations and little compromise. The liveliest in the group to drive, its interior size makes it the toughest to live with.

Seductive but confusing

The Subaru SVX is a seductive but confusing car, full of conflicts, such as its high-speed handling quirks and the lack of an automatic transmission. It's a terrific ride on the highway and a great head-turner—if its foibles don't get to you first. The BMW thus ends up as the best execution of a sports coupe, disregarding cost, while the Corrado is arguably the closest to a true sports car.

But the best combination of value, performance, and style is the Ford Probe, which manages to refine and improve on one of the best-performing sports coupes on the market today, ending up quicker, smoother, and better-handling—not to mention better-looking. Compared with the Mazda MX-6, the Probe is the more handsome face, and its quicker steering makes it more entertaining to drive. But the choice comes down to whether you prefer the utility of the Probe's hatchback design, which incidentally is a great way to get a bundle of 2x4s back from the home center.

But strap them down first. PS

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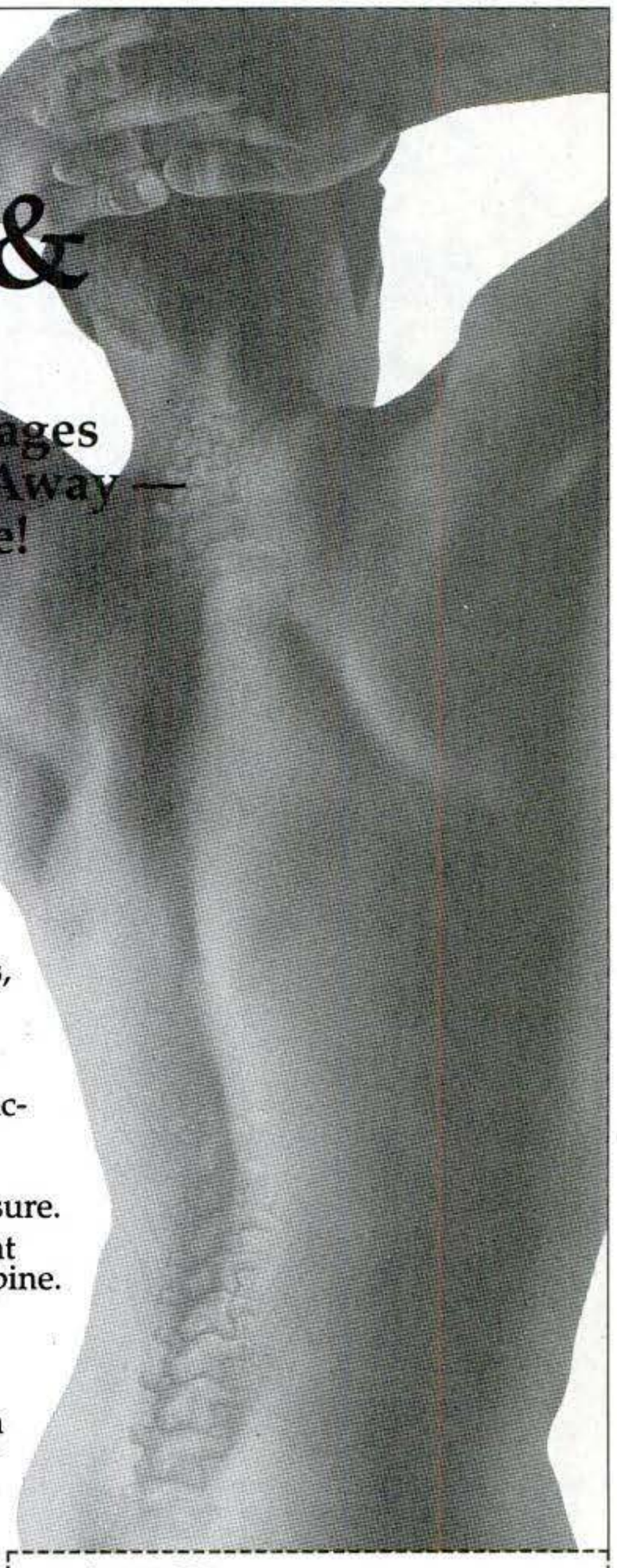

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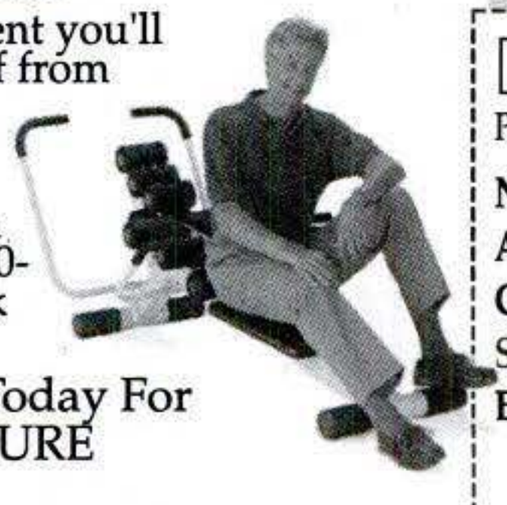

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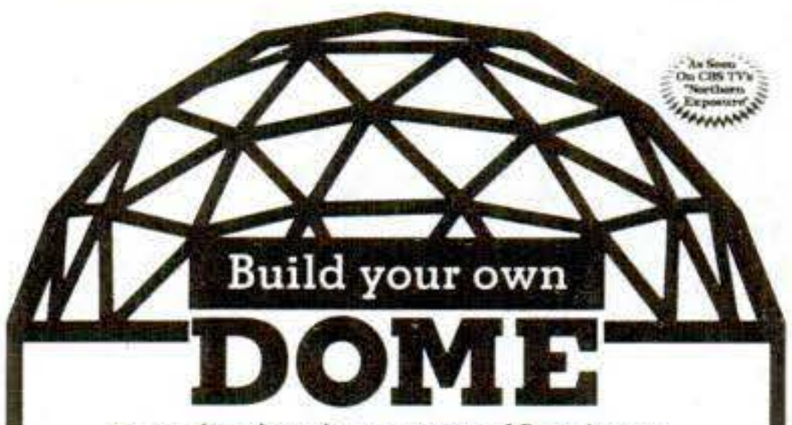

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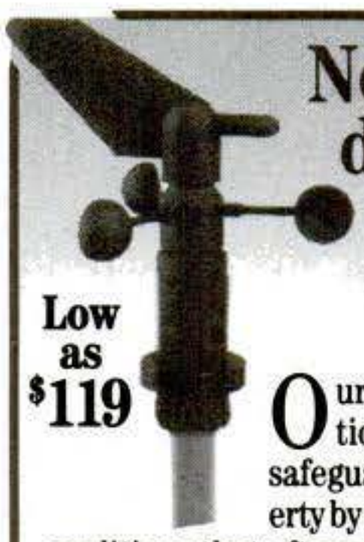

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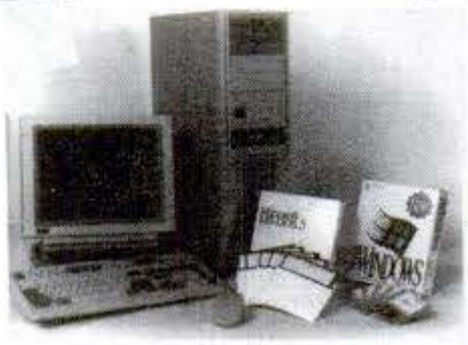

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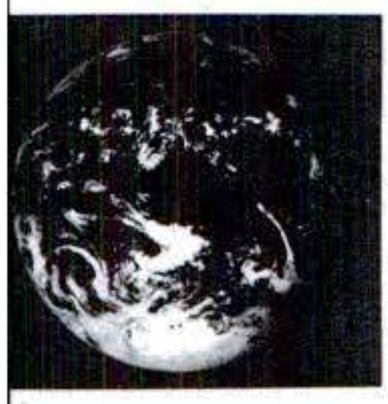

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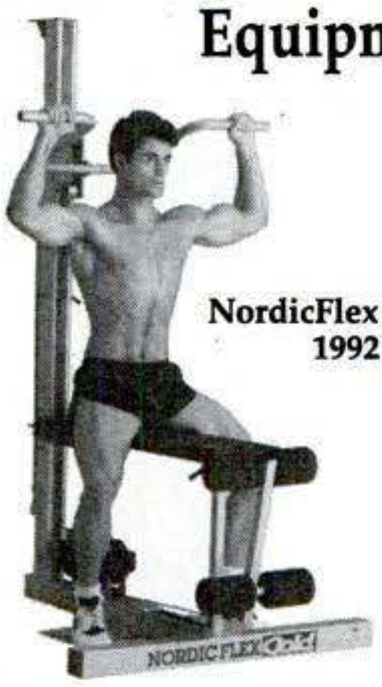

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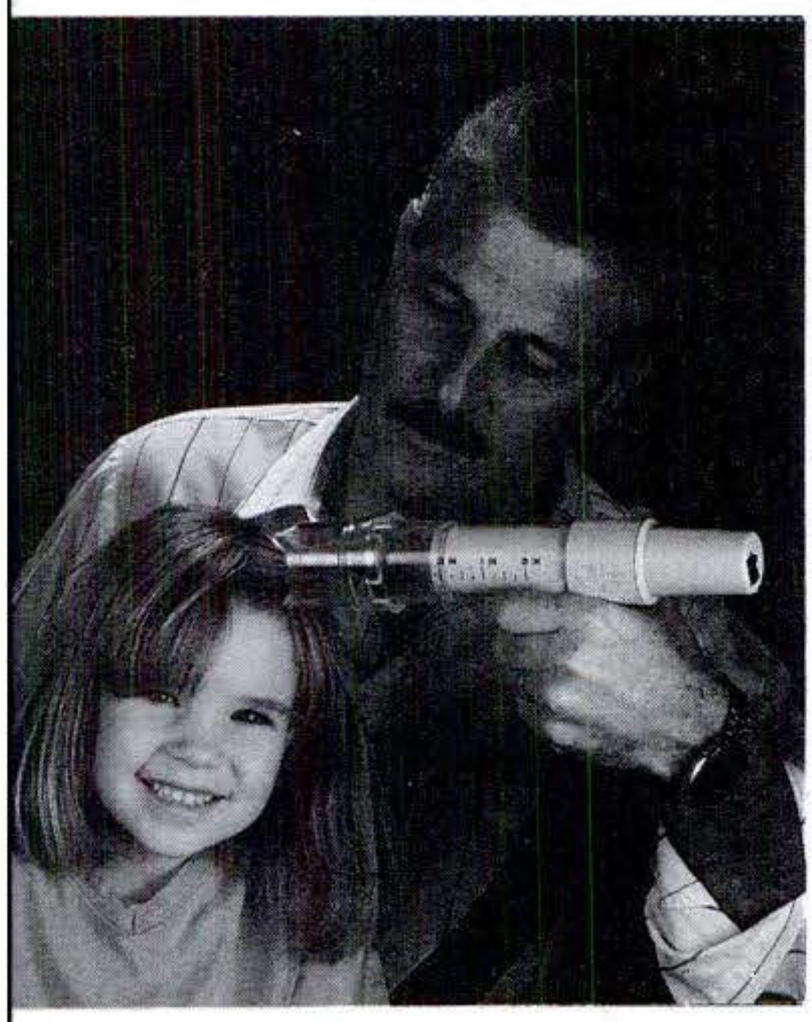

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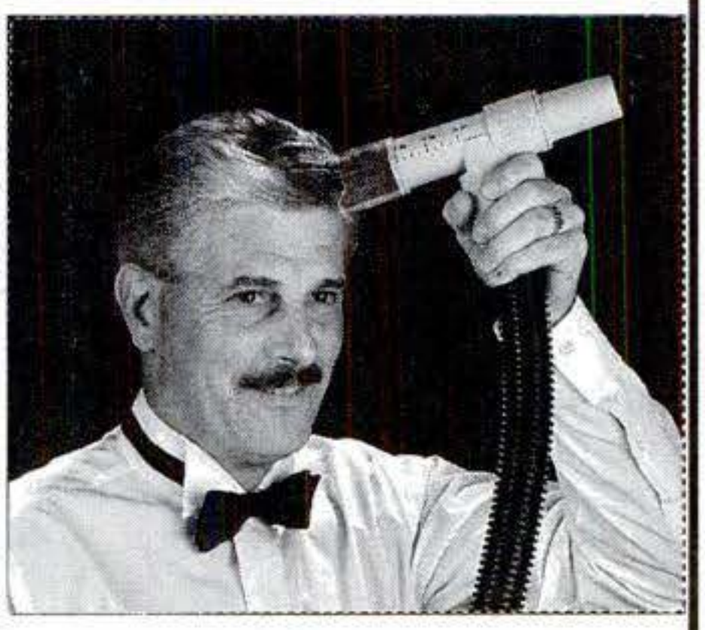

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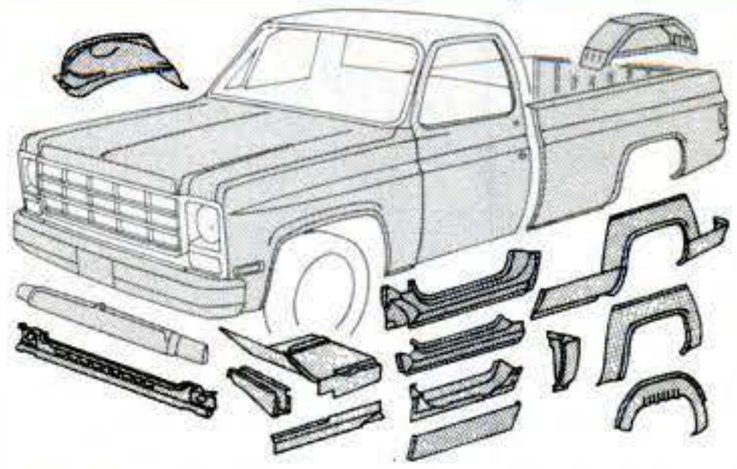

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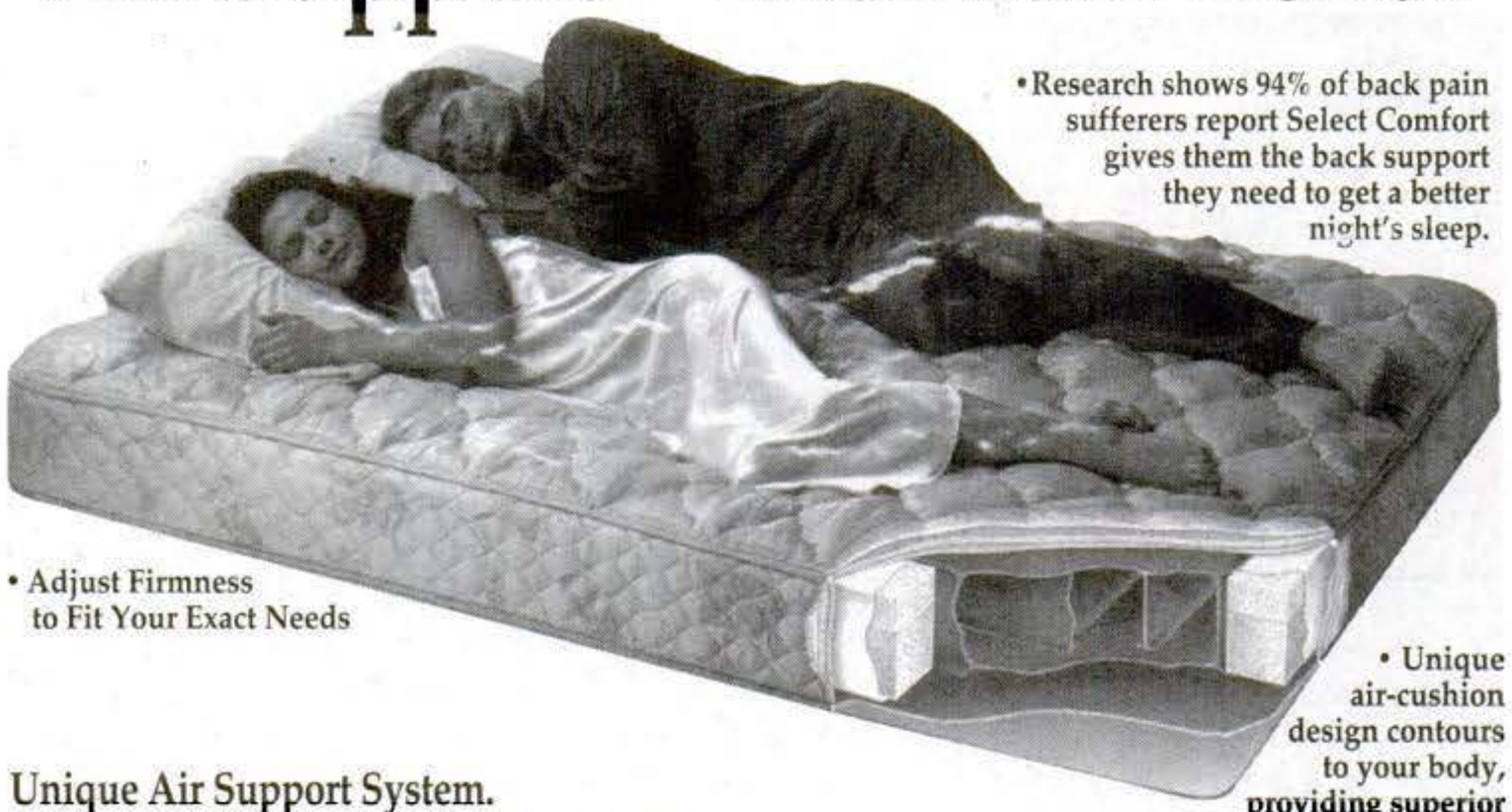

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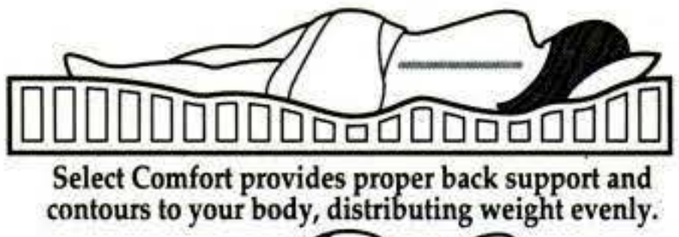

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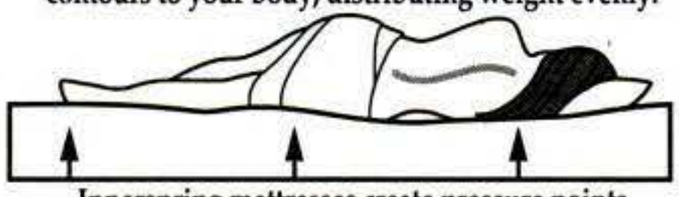

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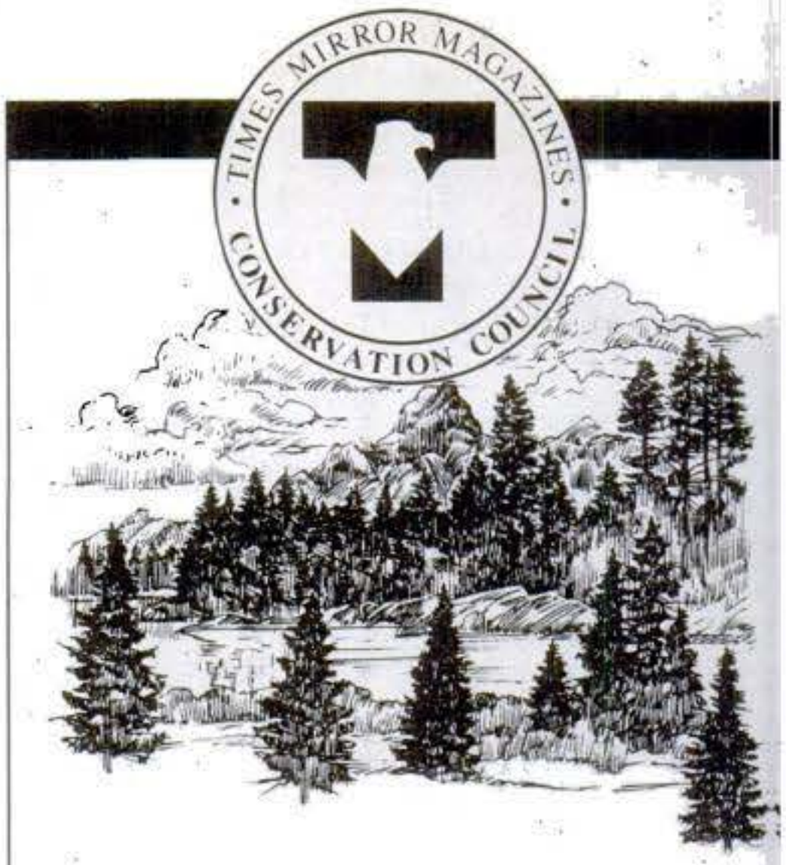

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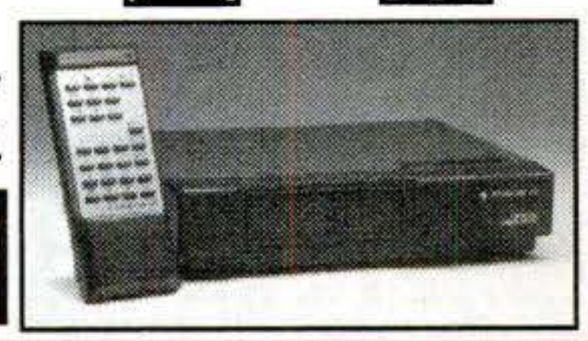

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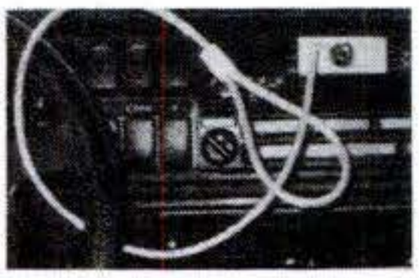

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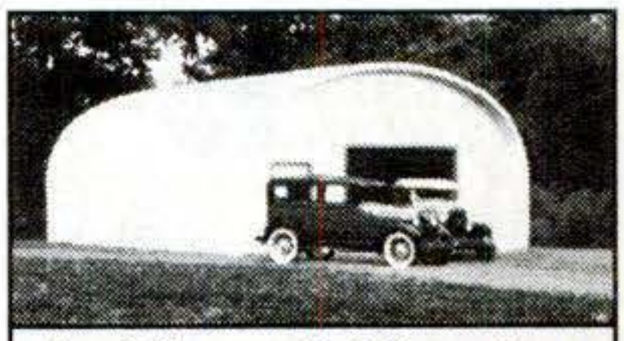

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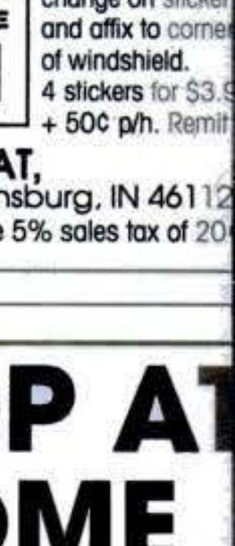

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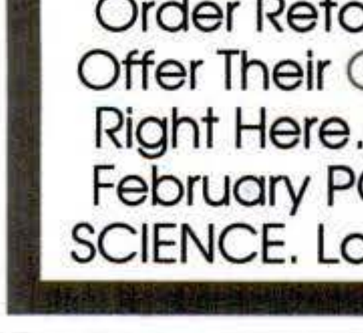

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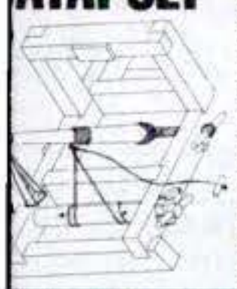

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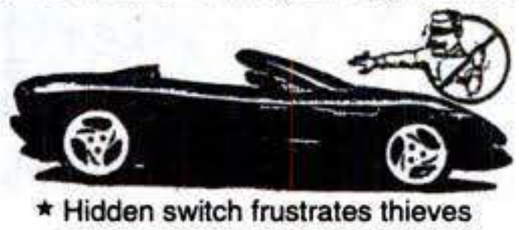

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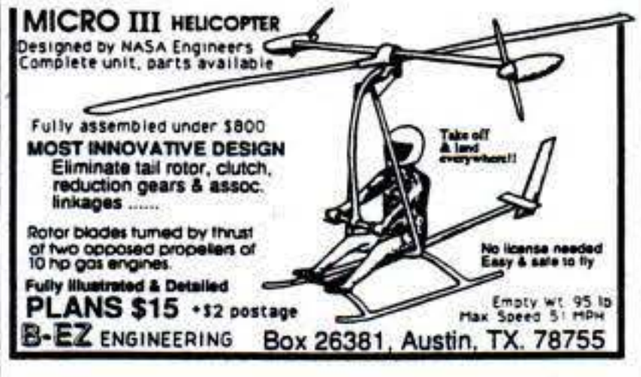

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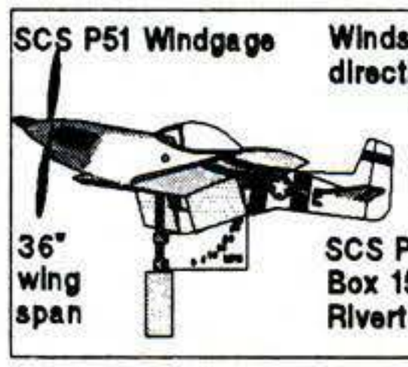

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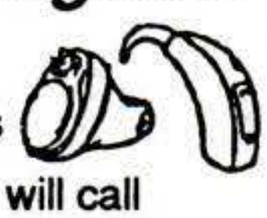

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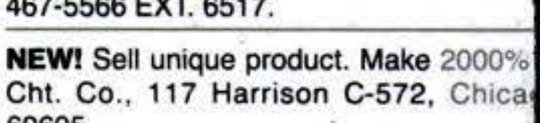

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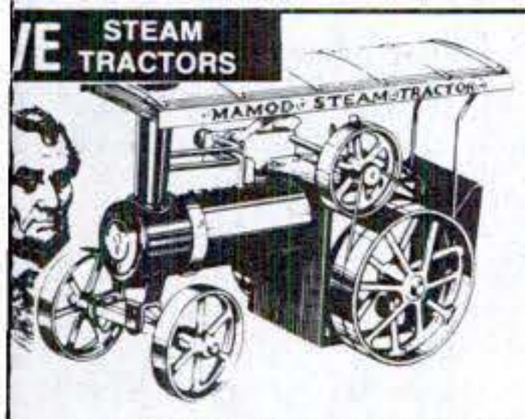

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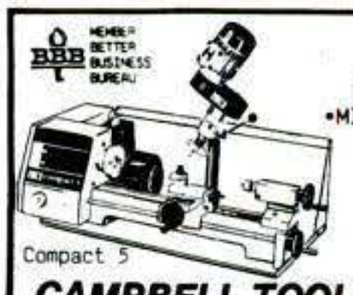

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Looking Back...

Sampling a century of POPULAR SCIENCE

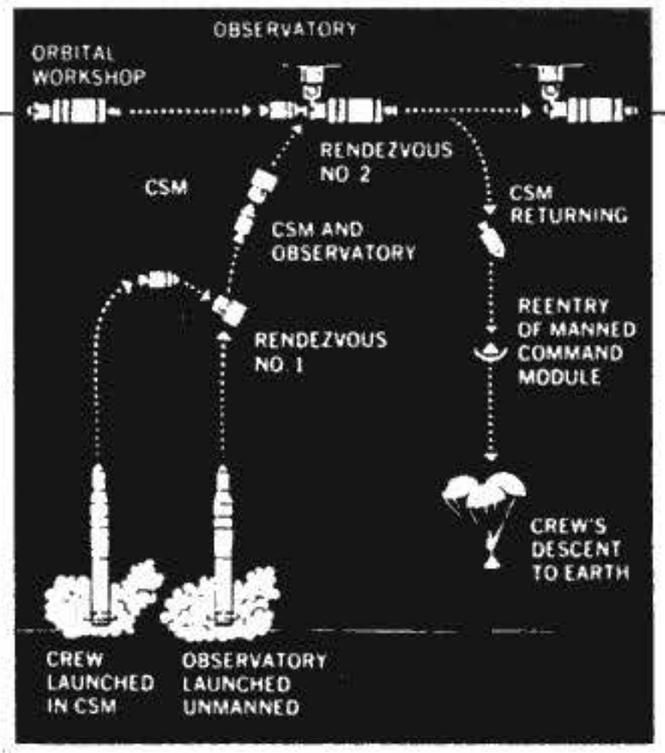
25 YEARS AGO — JANUARY 1968

A year or so after our first Apollo manned landing on the moon, NASA hopes to place in orbit around Earth our first manned astronomical observatory. The Apollo Telescope Mount, or ATM, will be operated by two astronaut-astronomers and carry the most powerful array of instruments ever assembled to probe the mysteries of the sun.

A double launch will put the ATM and its crew aloft:

First an Apollo Command and Service Module (CSM) will be boosted by an Uprated Saturn I rocket into a low parking orbit. It will carry a crew of three—the two ATM astronomers and a third astronaut who will have other space duties. Shortly afterward, another Uprated Saturn I will launch the ATM, unmanned, into a higher parking orbit.

The manned CSM will then rendezvous and dock with the ATM. The joined craft will ascend to another rendezvous-and-docking with the Orbital Workshop, a spent Saturn S-IVB rocket stage fitted with living quarters and left circling by a previous mission. The CSM and ATM will be docked to a multiple docking adapter at one end of the Saturn stage. Thus linked, the cluster will amount to an embryonic space station.



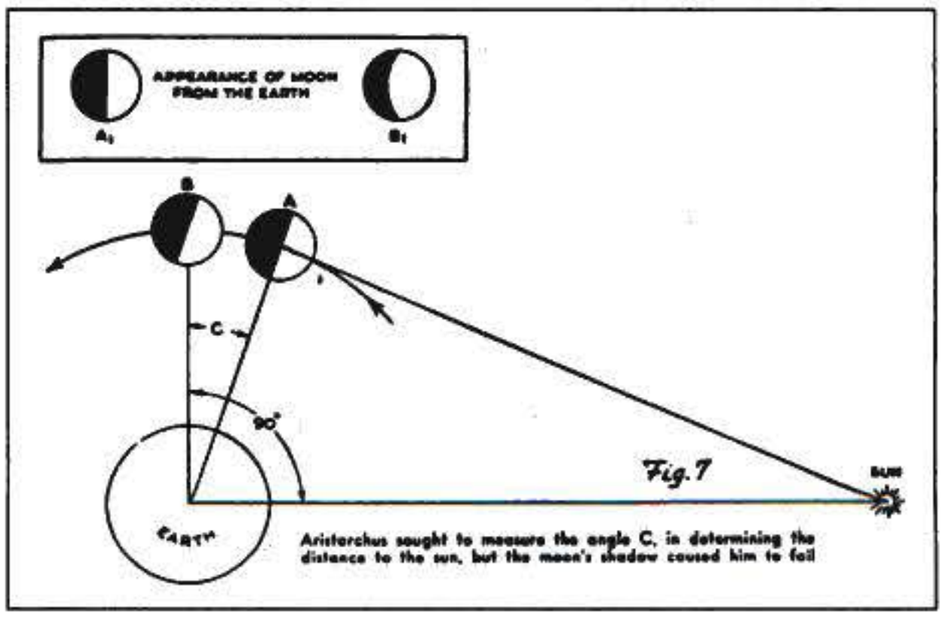
Astronauts will attempt to dock the Apollo Telescope Mount with the Orbital Workshop to create a manned space station.

At the end of their mission the two astronaut-astronomers will gather up their films and data and, joined by the third astronaut, board the CSM to return to Earth. They will leave the ATM attached to the circling Orbital Workshop for use by later missions.

50 YEARS AGO — JANUARY 1943

Ten years of mathematical calculation, following more than a year of extensive observation by astronomers from 15 countries, have established the distance from Earth to the center of the sun at 93,005,000 miles. The new figure, which replaces the previous best value of 92,900,000 miles, was obtained by methods basically similar to the triangulation used by surveyors and is accurate within 9,000 miles—an uncertainty that corresponds to the apparent breadth of a human hair at ten miles.

The first measurement of the distance from Earth to the sun was calculated by the Greek Anaxagoras in 434 B.C. He believed that Earth was flat and knew that the height of the sun above the horizon varies with the place of observation. Anaxagoras reasoned that this apparent displacement resulted from the sun's nearness and used this displacement to calculate its distance. The value he obtained was 12,500 miles.



Aristarchus tried to measure the distance to the sun by determining the angle C. The moon's shadow thwarted his efforts.

Aristarchus of Samos, about 200 years later, knew that Earth was round, that the planets moved in orbits around the sun, and that the sun's distance was at least 14 times greater than that of the moon, or in excess of about 3,000,000 miles.

Although this figure was short by a factor of 20, it remained essentially unchallenged until the latter part of the 17th century, and no result that even approximated the latest calculation was obtained until Lacaille, in 1752, achieved comparative success with triangulation.

100 YEARS AGO — JANUARY 1893

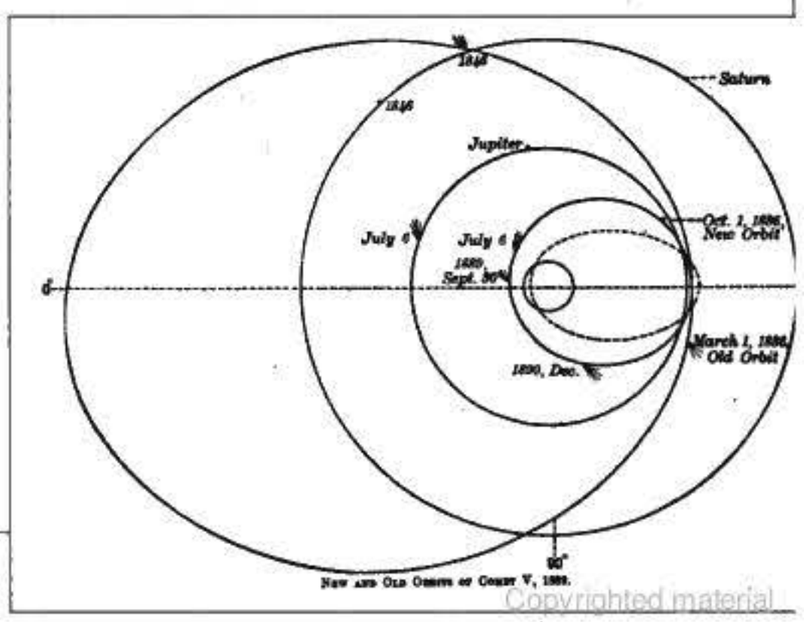
The comet discovered on July 6, 1889, has been identified as Lexell's lost comet, which disappeared 120 years before.

Only 20 years after Halley had made his great discovery of periodic comets—those that revolve around the sun in a predictable trajectory—Lexell identified the comet of 1770 as also belonging to this class of bodies.

Lexell demonstrated that this comet revolved around the sun in a five-and-a-half-year ellipse; but it had not always traveled in that path. He showed that the comet had passed very close to Jupiter in 1767, which altered its path so greatly that it had never before passed near enough to Earth to be seen. Lexell also predicted a second close approach of these two bodies in 1779, and said this might prevent the comet's reappearance after that date.

This second prediction of Lexell's was fulfilled—unless it can be proved that the comet discovered by Brooks in 1889 is the lost body.

These comets appeared utterly unalike: The comet of 1770 was large and bright, while the comet of 1889 was hardly visible even with powerful telescopes. But, by studying the movements of the two, it can be shown that the comets must have occupied the same position at one time—their identity then is self-evident.



Jupiter's gravity changed the orbit of this comet.

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